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JOURNAL OF PALEONTOLOGY

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CONTENTS

A foraminiferal fauna from the Kaiatan stage (upper Eocene) of New Zealand ..... *J. M. Dorreen* 281

Three notes on Ordovician cystids ..... *G. Winston Sinclair* 301

Middle Cambrian trilobites from the conglomerates of Quebec ..... *Franco Rasetti* 315

Lower Cambrian Pleospongia from the Purcell Range of British Columbia, Canada ..... *Vladimir J. Okulitch* 340

A Lower Permian ammonoid fauna from New Mexico ..... *A. K. Miller and Eldon J. Parizek* 350

A small amphibian from the Triassic of Howard County, Texas *John Andrew Wilson* 359

Fossil Helioporidae from Japan and the South Sea Islands ..... *Motoki Eguchi* 362

A new *Spongiomorpha* from the *Orbitolina* sandstone of Iwate prefecture, and its significance in Japan ..... *Motoki Eguchi* 365

PALEONTOLOGICAL NOTES

Cope's types of fossil fishes in the collection of the Bureau of Economic Geology, The University of Texas ..... *John Andrew Wilson* 368

Paleogeography and nomenclature ..... *Eugene S. Richardson, Jr.* 369

Orthography and type designation of *Dictyoconus* Blanckenhorn (Foraminifera) ..... *Don L. Frizzell* 370

Cocoa sand type locality ..... *William D. Turnbull* 372

Cambrian Bryozoa more precisely dated ..... *Madeleine A. Fritz* 373

Dicaelosia versus *Bilobites*. *Preston E. Cloud Jr.* 373

An Ordovician trilobite and some later Paleozoic Crustacea in moulting positions ..... *Martin F. Glaessner* 374

SOCIETY RECORDS AND ACTIVITIES

Officers, correspondents, fellows and members of the Paleontological Society 375

Nominations for offices in the Paleontological Society for 1949 387

Abstracts and nominations 387

NOTICES 388

EDITORS

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VOLUME 22 MAY, 1948 NUMBER 3

A FORAMINIFERAL FAUNA FROM THE KAIATAN STAGE (UPPER EOCENE) OF NEW ZEALAND

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ABSTRACT—Sixty-six Foraminifera are recorded from the Upper Eocene Kaiatan stage of New Zealand. The list includes three new genera, twenty-one new species and two new varieties. The fauna is of sublittoral tropical type.

INTRODUCTION

THE MATERIAL for this report was collected in 1940, during a brief visit to the area. It should be noted that this fauna, although containing sufficient positive elements to correlate it with equivalent strata elsewhere in New Zealand, differs considerably from coëval faunas from other localities. This assemblage appears rather, to consist largely of foreign tropical species which failed to establish themselves due to different environmental conditions. It is recorded here mainly in the hope that it may prove useful in correlations with outside countries.

Collecting was carried out along both banks of Ethel Creek, about five miles southeast of Greymouth (figures 1, 2).

The beds exposed on the creek banks consist of soft to firm, blue-gray clay with much included incoherent sand and coal fragments, which, in places, form small veins, pockets, and lenses. Bryozoan fragments are common.

STRATIGRAPHY

Table 1 shows the stratigraphic succession in this area correlated with the standard succession for New Zealand with tentative ages assigned.

From the Stillwater area, some 15 miles east of Greymouth, to the seaward slopes of the hills around Greymouth itself, a well developed section of formations ranging from Eocene to Miocene is exposed. These formations all have a general westerly dip, so, as one proceeds from Stillwater to Greymouth, progressively younger formations are encountered. These formations have been considered to fall into two groups or series, for the lower of which Morgan (1918, p. 40; 1922, p. 52) proposed the name Mawheranuian, which, in the Greymouth Subdivision included the following formations (in descending order).

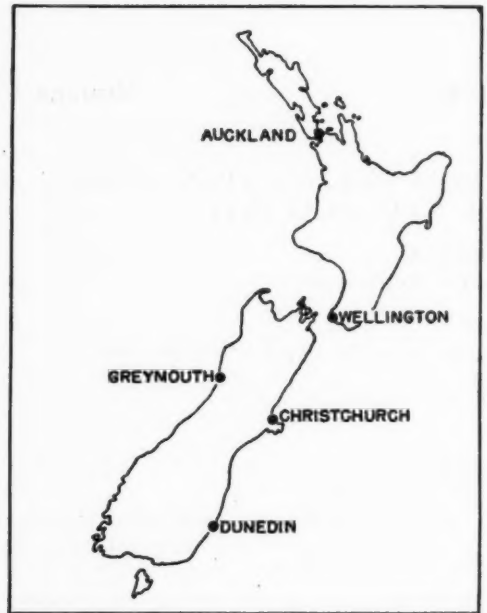
(a) Kaiata mudstone (marine)
(b) Island sandstone (estuarine-marine)
(c) Brunner beds (non marine)
(d) Paparoa beds (non marine)

The Greymouth Series (Henderson: 1929, p. 283) rests directly on the Kaiata mudstone and was subdivided in descending sequence as follows:

(a) Cobden limestone
(b) Point Elizabeth beds
(c) Omotumotu beds

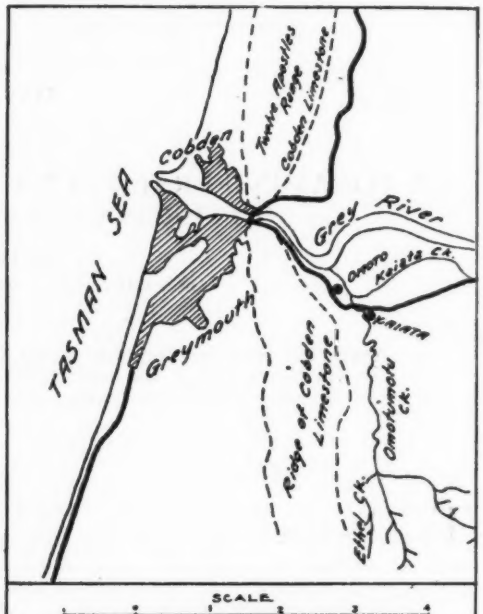
The Miocene Lower Blue Bottom forma-

tion, outcropping on the seaward side of the Cobden Limestone hills, completes the section. This formation was named by the alluvial gold miners, who, when working the overlying auriferous Pleistocene gravels, regarded this prominent blue shale as the



OUTLINE MAP OF NEW ZEALAND

FIG. 1



GREYMOUTH AREA SHOWING ETHEL CREEK WHERE COLLECTIONS WERE MADE

FIG. 2

bottom point of their sluicing and digging operations.

Stratigraphic position of the Fauna.—The fauna described in this report comes from near the top of the Omotumotu formation about 200 feet upstream from the mouth of Ethel Creek.

The Kaiatan stage.—For the interval of time between the Bortonian (Ypresian-Lutetian?) and Hutchinsonian (Aquitanian?) stages, J. A. Thomson (1916), pp. 34–35) proposed the name Ototaran, after the Ototara Limestone of the Oamaru District. R. S. Allan (1933: p. 92) defined the Ototaran Stage and stated that, at the time of writing, "it (was) impossible to cite the characteristic fossils of the Ototaran Stage except in a very general way."

H. J. Finlay's more recent work on Foraminifera has revealed the existence of two very distinct faunas in the Ototaran; that of the Upper Ototaran being coëval with the fauna described by Stache (1864) from Whaingaroa Harbour, and that of the Lower Ototaran having stronger affinities with the Bortonian. For the interval of time represented by this Lower Ototaran assemblage, Finlay (1939, p. 531) proposed the stage name Kaiatan based on the Kaiata mudstone of the Greymouth Subdivision. Later Finlay and Marwick (1940: p. 110) defined the Kaiatan as "that period of deposition between the Bortonian Island sandstone and the Whaingaroan (Upper Ototaran) Upper Point Elizabeth beds." Hence, the Lower Point Elizabeth beds, Omotumotu

beds, and the Kaiata mudstone are, by definition, included in the Kaiatan Stage and we are thus dealing with a fauna from the type Kaiatan exposure.

ENVIRONMENT OF DEPOSITION

Unfortunately material is not at hand to make a complete analysis of the ecologic environment of this faunule. However, it is clearly indicative of very shallow tropical water. Such elements as *Peneroplis*, Cymbaloporidae, *Hauerina*, and Nummulitidae are strongly stenothermal and can be found today in beach sand throughout the tropical seas.

Stomatorbina torrei and closely allied forms (for *Pulvinulina concentrica* see discussion under *Stomatorbina*) have a wide range in the tropics, being recorded from Hawaii, the Philippines, South Pacific, Australia, Kerimba, the Mediterranean and the Eocene of Cuba. The genus *Glabratella* is common in the Miocene Filter Quarry beds of Australia (Heron-Allen & Earland, 1923) and as *G. pulvinata*, it occurs widely in tropical waters. *Hauerina* and *Flintina* occur in shallow tropical seas. *Amphistegina* is stated by Cushman to be "most common in shallow warm water." *Planorbulina* is a common warm to tropical shallow water species and *Carpenteria* similarly favours warm Indo-Pacific waters. From this evidence it is suggested that this assemblage arrived as a migrant fauna along some tropical ocean current, which probed into the more temperate New Zealand waters in the Upper Eocene.

The presence of *Halkyardia*, *Nummulitella*, etc. imply a connection with the Mediterranean regions by way of the Tethyan Sea and the presence of so many shallow water species would appear to indicate that no deep open seas stood as barriers across the route of migration, but that from equatorial regions to New Zealand there was shallow water, possibly interspersed with island chains. The submarine ridge connecting New Zealand with New Caledonia and extending to New Guinea is a possible route of migration and it would be interesting to see if any Upper Eocene beds of similar facies from these two islands yield species in common with the Kaiatan.

A fauna containing exotic genera and species similar to those found in this Kaiatan fauna is known from the Bortonian (Lutetian?) Eyre River chalk beds of Oxford, Canterbury on the east coast of New Zealand. Common to both faunas we have:

Gaudryina minuscula?
Listerella sp.
Globulina gibba
Discorbis finlayi
Glabratella crassa
Eponides tethycus
Stomatorbina torrei

TABLE 1. STRATIGRAPHIC SUCCESSION IN GREYMOUTH AREA WITH AGES ASSIGNED

FORMATIONS IN GREYMOUTH AREA	NEW ZEALAND STAGES	AGE
Lower Blue Bottom	Ihungian	Lower Miocene
Cobden Limestone	Whaingaroan	Lower Oligocene
Upper Point Elizabeth Beds		
Lower Point Elizabeth Beds	Kaiatan	Upper Eocene
Omotumotu Beds		
Kaiata Mudstone		
Island Sandstone	Bortonian	Middle Eocene
Brunner Beds	Lower Bortonian?	Lower Eocene?
Paparoa Beds		

TABLE 2. LIST OF SPECIES RECORDED FROM THE OMOTUMOTU FORMATION AND THEIR OCCURRENCES IN THE LOWER OTOTARAN LIMESTONE OF KAIATAN AGE, THE MIDDLE EOCENE OXFORD CHALK AND THE OLIGOCENE MAHOENUI MUDSTONE

Foraminifera recorded from Omotumotu Beds	Occurring in Lower Ototaran (Kaiatan) Lst. of Jackson's Paddock Oamaru	Occurring in Eyre River *Discocyclina* Chalk	Occurring in Mahoenui of Taranaki
Textularia aorangi Dorreen, n. sp.			
Textularia zeaggluta Finlay	x		
Gaudryina minuscula? Finlay	x	x	x
Karreriella novozealandica Cushman	x		
Listerella sp.	x	x	
Arenodosaria kaiataensis Dorreen, n. sp.			
Arenodosaria robusta (Stache)	x		x
Quinqueloculina sp. aff. *plana* d'Orbigny			
Quinqueloculina striata d'Orbigny			
Hauerina notoensis Dorreen, n. sp.			
Flintina novozealandica Dorreen, n. sp.			
Pyrgo sp.			
Robulus gyroscalprum (Stache)	x		x
Marginulina hochstetteri Stache	x		
Marginulina subbullata Hantken			
Nodosaria cf. *crassitesta* Schwager			
Nodosaria cf. *hispida* d'Orbigny, var. *agglutinans* Perner	x		
Nodosaria longiscata d'Orbigny	x		x
Saracenaria kellumi Dorreen, n. sp.	x		x
Guttulina sps.	x		x
Polymorphina (*Globulina*) *gibba* d'Orbigny	x	x	
Nonion maoricum (Stache)	x		
Elphidium ingressans Dorreen, n. sp.			
Elphidium nitidum Dorreen, n. sp.			
Elphidium omotoensis Dorreen, n. sp.	x		x
Notorotalia tainuia Dorreen, n. sp.	x		
Nummulitella polystylata Dorreen, n. sp.			
Peneroplis mauii Dorreen, n. sp.			
Buliminella cf. *turbinata* (Terquem)			
Bulimina pupula Stache			
Bolivina sp.			x
Reussella finlayi Dorreen, n. sp.			
Uvigerina bortotara (Finlay)			
Uvigerina bortotara (Finlay) var. *costata* Dorreen			
Rectuvigerina prisca (Finlay)			
Angulogerina elliptica Dorreen, n. sp.	x		
Discorbis finlayi Dorreen, n. sp.	x	x	x
Discorbis galerus Finlay			
Glabratella crassa Dorreen, n. sp.		x	
Gyroidina zelandica Finlay	x		
Eponides dorsopustulatus Dorreen, n. sp.			
Eponides tethycus Dorreen, n. sp.	x	x	x
Epistomina elegans (d'Orbigny)			x
Stomatorbina torrei (Cushman and Bermudez)	x	x	x
Stomatorbina sp.			
Lamarckina novozealandica Dorreen, n. sp.			x
Lamarckina turgida Dorreen, n. sp.			
Ceratobulimina lornensis Finlay			
Cerobertina kakahoica Finlay			
Robertina lornensis Finlay			
Asterigerina cyclops Dorreen, n. sp.			
Amphistegina, sp.			

TABLE 2—(*continued*)

Foraminifera recorded from Omotumotu Beds	Occurring in Lower Ototaran (Kaiatan) Lst. of Jackson's Paddock Oamaru	Occurring in Eyre River *Discocyclina* Chalk	Occurring in Mahoenui of Taranaki
Halkyardia bartrumi Parr			
Cassidulina cf. *subglobosa* Brady	x		x
Pullenia sphaeroides d'Orbigny	x		x
Sphaeroidina bulloides d'Orbigny	x		x
Globigerina linaperta Finlay	x	x	
Globigerinoides index Finlay	x		
Cibicides perforatus (Karrer)	x	x	x
Cibicides perforatus (Karrer) var. *notocenicus* Dorreen, n. var.			x
Cibicides pseudoconvexus Parr	x	x	
Cibicides vortex Dorreen, n. sp.			
Planorbulina aff. *mediterranensis* d'Orbigny		x	x
Carpenteria aff. *bulloides* Galloway and Heminway	x		

Globigerina linaperta
Cibicides perforatus
Cibicides pseudoconvexus
Planorbulina aff. *mediterranensis*

The Eyre River chalk contains *Discocyclina*, *Asterocyclina*, and *Assilina*, so an earlier transgression of the same Tethyan Sea is postulated. The exotic species of both these invasions quickly became extinct in the New Zealand region and the last appearance of any of them is in the Mahoenui (Uppermost Oligocene?) Beds of Taranaki (table 2).

Evidence for Eocene age.—Finlay and Marwick (1940: p. 81) place the Kaiatan Stage in the Lower Oligocene and the Tahuian Stage in the Upper Eocene. The latter has, however, long been an unsatisfactory stage especially from a point of view of foraminiferal faunas and it appears better, at least for the present, to regard both stages as being contemporaneous. Three factors lead me to assign an Eocene age to the Kaiatan:

(1) The faunal affinities are with the underlying Bortonian, rather than with the overlying Whaingaroan.

(2) *Hantkenina australis* is found in Kaiatan beds of suitable facies at the type locality. Thalmann (1942, p. 818) mentions the occurrence of *H. australis* in the basal Kaiatan and suggests that it is allochthonous. It can, however, occur at least as high in the Kaiatan as the Omotumotu formation and must be considered autochthonous and indicative of Eocene age.

(3) *Halkyardia bartrumi* occurs in the fauna described in this report. The genus, described from the Eocene of France by Heron-Allen and Earland (1919) has for some time been considered as restricted to the Eocene. However, H. H. Renz, in a personal communication, states that in Trinidad, it occurs in the Upper Eocene San Fernando formation and along the Cipero coast ranges into beds which are probably basal Oligocene. Therefore, it would appear that not too much reliance could be placed on a determination of Eocene age, based solely on the genus, but I believe that to faunas in which the genus occurs an Eocene age should be tentatively allotted, provided that there is no good evidence to the contrary.

In the case of the Kaiatan, the fauna must be either Upper Eocene or basal Oligocene and the microfaunal evidence favours the former.

ACKNOWLEDGMENTS

The author is indebted to Mrs. H. J. Plummer for criticism and for many helpful suggestions; to Dr. J. A. Cushman for suggestions and for supplying some type specimens; to Dr. H. V. Howe for specimens of *Mississippina* and to Mr. B. Stone for helpful assistance.

Permission to publish has been granted by Standard Vacuum Oil Company.

Drawings were made by the author with the help of a camera lucida.

Holotypes and paratypes will be deposited in the Cushman Laboratory.

Unless otherwise stated, the holotypes are all from the Omotumotu formation, Kaiatan stage, of Ethel Creek, Greymouth District, New Zealand.

Method of Classification.—Cushman's classification has been adopted here with the exception of the family Ceratobuliminidae, Glaessner, which has been included.

SYSTEMATIC DESCRIPTIONS

Family TEXTULARIIDAE
Subfamily TEXTULARIINAE
Genus TEXTULARIA Defrance, 1824

TEXTULARIA ZEAGGLUTA Finlay
Plate 36, figure 1

Textularia zeaggluta FINLAY, 1939, Trans. Roy. Soc. New Zealand, vol. 69, pt. 1, p. 89, pl. 14, figs. 65, 66.

Occurs in typical form. Uncommon.

TEXTULARIA AORANGI Dorreen, n. sp.
Plate 36, figures 2a, 2b

Conical test, sides diverging at about 45°, outline nearly circular in section; chambers biserial, concave proximally with considerable degree of overlap; median longitudinal plane of symmetry twists about 10° from distal to apertural end, interior of chambers simple without secondary partitions, sutures flush with surface, expressed externally by dark lines; wall finely arenaceous; aperture a low elongate arch at base of last chamber.

Dimensions of holotype: Length 0.60 mm., breadth 0.60 mm.

Rare.

This species resembles *Textularia trochus* d'Orbigny in rotundity, degree of overlap of chambers, concave proximal end and type of aperture; it differs in possessing non-limbate sutures and a more even slope of sides.

Family VERNEUILINIDAE
Genus GAUDRYINA d'Orbigny, 1839

GAUDRYINA MINUSCULA? Finlay
Plate 36, figures 3a, 3b

Gaudryina minuscula FINLAY, 1940, Trans. Roy. Soc. New Zealand, vol. 69, pt. 4, pl. 65, fig. 147.

From the common occurrence of this species and its range in the older Tertiary strata of New Zealand I consider that this is probably Finlay's species, which was figured but not described.

This species has been noted rarely as early as Upper Bortonian, becoming abundant in the Kaiatan it ranges into the Mahoenui of Taranaki.

Family VALVULINIDAE
Subfamily EGGERELLINAE
Genus KARRERIELLA Cushman, 1933

KARRERIELLA NOVOZEALANDICA Cushman
Plate 36, figures 4a, 4c

Karreriella novozealandica CUSHMAN, 1936, Cushman Lab. Foram. Research, Spec. Publ. no. 6, p. 37, pl. 5, figs. 18 a, b.

Karreriella novozealandica CUSHMAN, 1937, *ibid.*, Spec. Publ. no. 8, p. 133, pl. 15, fig. 9.

This species described from the "Miocene of Motatura" New Zealand occurs frequently. Specimens in which the aperture is poorly preserved are easily mistaken for *Dorothia*. Finlay (1940, pt. 4, p. 451) has pointed out that this locality is probably Motutara Point, Kawhia Harbour, and that the range of this species is Lower Bortonian to Whaingaroan.

Genus LISTERELLA Cushman, 1933

LISTERELLA sp.

Two specimens were found of a small, possible immature, *Listerella*. It agrees in size with *Listerella levis* Finlay, but the initial stages are much more obscure than in *L. levis*.

Genus ARENODOSARIA Finlay, 1939

ARENODOSARIA ROBUSTA (Stache), 1864

Clavulina robusta STACHE, 1864, Novara Exped., Geol. Theil, vol. 1, p. 169, pl. 21, figs. 9, 10.

Arenodosaria robusta (Stache), FINLAY, 1939, Trans. Roy. Soc. New Zealand, vol. 69, pt. 1, p. 95.

Broken specimens showing typical early portions and apertures occur rarely.

ARENODOSARIA KAIATAENSIS Dorreen, n. sp.
Plate 36, figure 5

Test cylindrical elongate, uniserial portion forms about six-sevenths of test, initial portion polyserial, number of chambers rapidly becoming reduced to three chambers per whorl, very short biserial stage followed by uniserial arrangement; no sutures visible in initial portion; in uniserial portion sutures are marked by annular constrictions; wall coarsely arenaceous, sugary in appearance; aperture a simple, terminal, rounded opening.

Dimensions of holotype: Length 1.45 mm., width 0.30 mm.

Rare.

At first this form was mistaken for *Clavulina*, which it resembles in external appearance. However, on using Mrs. Plummer's method of dissolving the test with very weak acid, applied by a fine brush, the chamber arrangement was seen to place it in the Valvulinidae. This very useful method of slow acid dissolution of the test was used with many of the specimens recorded here.

Family MILIOLIDAE

Genus QUINQUELOCULINA d'Orbigny, 1826

QUINQUELOCULINA sp. aff. PLANA d'Orbigny
Plate 36, figures 6a, 6b

Quinqueloculina plana D'ORBIGNY, 1850, Prodrome de Paléontologie stratigraphique universelle des animaux mollusques et rayonnés., vol. 2, p. 409.

Quinqueloculina plana d'Orbigny, FORNASINI, 1905, Mem. R. Accad. Sci. Inst. Bologna, ser. 6, vol. 2, pl. 2, fig. 9.

The New Zealand form seems to be very close to, if not identical with the species described by d'Orbigny from the Paris Eocene. It occurs abundantly in this fauna.

QUINQUELOCULINA STRIATA d'Orbigny
Plate 36, figures 7a, 7b

Quinqueloculina striata D'ORBIGNY, 1826, Ann. Sci. Nat., vol. 7, p. 301. (nom. nud.)

Quinqueloculina striata d'Orbigny, GUÉRIN-MÉNEVILLE, F. E., 1843, Iconographie du Régne Animal de G. Cuvier; Mollusques, p. 10, pl. 3, fig. 10.

Quinqueloculina striata d'Orbigny, FORNASINI, 1905, Mem. R. Accad. Sci. Inst. Bologna, ser. 6, vol. 2, pl. 2, fig. 7.

This New Zealand species appears to have chambers squarer in cross section than the European species. However, as general form, size, chamber arrangement, surface striae and aperture appear to be identical in both forms I should hesitate to separate them before studying topotypes of *Q. striata* to see how much variation is permissible. It is interesting to note that this species lends weight to the hypothesis of a Tethyan extension from the Mediterranean to New Zealand at this time. The species occurs fairly commonly.

Genus HAUERINA d'Orbigny, 1839

HAUERINA NOTOENSIS Dorreen, n. sp.
Plates 36, figures 9a–9d

Planispiral involute in adult; perfect specimens with thin, transparent, covering layer of shell material, through which are seen large pores or canal openings; between sutures the pores are arranged rectilinearly in parallel rows, each row marking the course of a canal, these radial canals showing prominently in decorticated specimens; wall thick, traversed by a system of short vertical canals which open into the chambers; early chambers quinqueloculine, adult spiroloculine, involute; number of chambers in adult whorl unknown, figured adult specimen suggests six; aperture cribrate, pore pattern forming an elongate ellipse in the terminal face.

Dimensions of holotype: Greatest diameter 0.80 mm., thickness 0.20 mm.

Rare.

In degree of involution this species resembles *H. occidentalis* Cushman. Dr. Cushman pointed out that *H. notoensis* bears a resemblance to his genus *Polysegmentina*, which occurs in Australian waters. However, the early chambers of *H. notoensis* preclude a position in the Ophthalmidiidae.

Genus FLINTINA Cushman, 1921

FLINTINA NOVOZEALANDICA Dorreen, n. sp.
Plate 36, figures 8a, 8b

Shell composed of quinqueloculine, followed by triloculine juvenile portions, with nearly planispiral chamber arrangement in the adult stage, three chambers to a complete cycle; chambers about three times as long as broad, triangular in transverse section with sharp outer longitudinal keel; surface of each chamber covered with fine parallel longitudinal striae; aperture trian-

gular in triloculine juvenile, apex directed outwards, long and narrow in planispiral adult, protected by two raised flanges, one on each side, which do not join around the periphery, but leave a small gap. No tooth noted.

Dimensions: Length 0.65 mm., thickness 0.30 mm.

Common.

This is a distinctive species, which may prove to be of stratigraphic value. The tooth of *Flintina* apparently may show considerable variation and the fact that this species does not appear to possess one I do not regard as being of more than specific importance.

Genus PYRGO Defrance, 1924

PYRGO sp.

A medium sized elongate *Pyrgo* is common. No complete specimens were found.

Family LAGENIDAE
Subfamily NODOSARIINAE
Genus ROBULUS Montfort, 1808

ROBULUS GYROSCALPRUM (Stache)
Plate 37, figures 1a, 1b

Cristellaria gyroscalprum STACHE, 1864, Novara Exped., Geol. Theil, vol. 1, p. 245, pl. 23, figs. 22.a, b.

Although Stache's figure does not show the fine volute lines in the peripheral flange extending backwards from the foramina, I believe that this species is identical with Stache's Whaingaroan form. Less perfect preservation would prevent these growth lines from being seen. Occurs frequently.

Genus MARGINULINA d'Orbigny, 1806

MARGINULINA HOCHSTETTERI Stache, 1864
Plate 37, figure 3

Cristellaria (*Marginulina*) *hochstetteri* STACHE, 1864, Novara Exped., Geol. Theil, vol. 1, p. 220, pl. 22, fig. 55.

This striking highly ornamented species is characteristic of Bortonian to Whaingaroan beds in New Zealand. It occurs rarely in this fauna.

MARGINULINA SUBBULLATA Hantken
Plate 37, figure 2

Marginulina subbullata, HANTKEN, M. VON, 1875, Die Fauna der Clavulina Szabói-Schichten; Theil 1—Foraminiferen, K. Ungar. Geol. Anst., Mitt. Jahrb., vol. 4, pt. 1, p. 46, pl. 4, figs. 9–10, pl. 5, fig. 9.

Two specimens were found which may be referred to this species.

Genus NODOSARIA Lamarck, 1812

NODOSARIA sp. cf. HISPIDA d'Orbigny var. AGGLUTINANS Perner
Plate 37, figure 5

Nodosaria hispida d'Orbigny var. *agglutinans* PERNER, 1897. Foraminifery urstev belohorských. Ceská Akad. Cisare Frantiska Josefa, Pal. Bohemiae, Trída 2, Nr. 4, p. 64, pl. 2, figs. 10–12.

Nodosaria hirsuta d'Orbigny var. *sublineata* Brady. CHAPMAN, 1926, The Cretaceous and Tertiary Foraminifera of New Zealand, New Zealand Geol. Survey, Pal. Bul., no. 11, p. 51, pl. 11, fig. 6.

This is a distinctive species, but as the only specimens found have been broken ones, no description is attempted. Chapman's figure clearly shows little resemblance to *N. hirsuta*, or to the variety described by Brady, both of which are characterized

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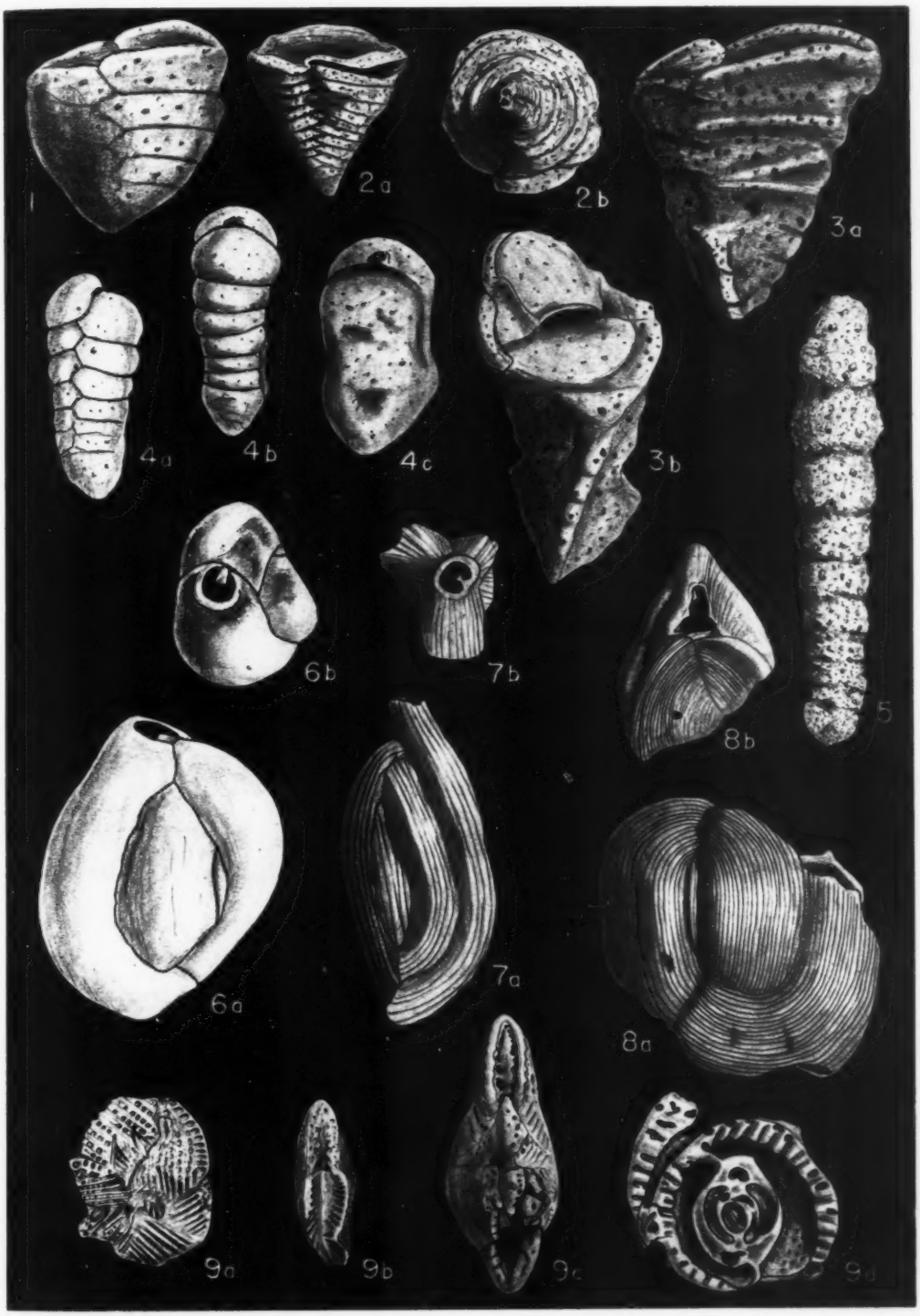
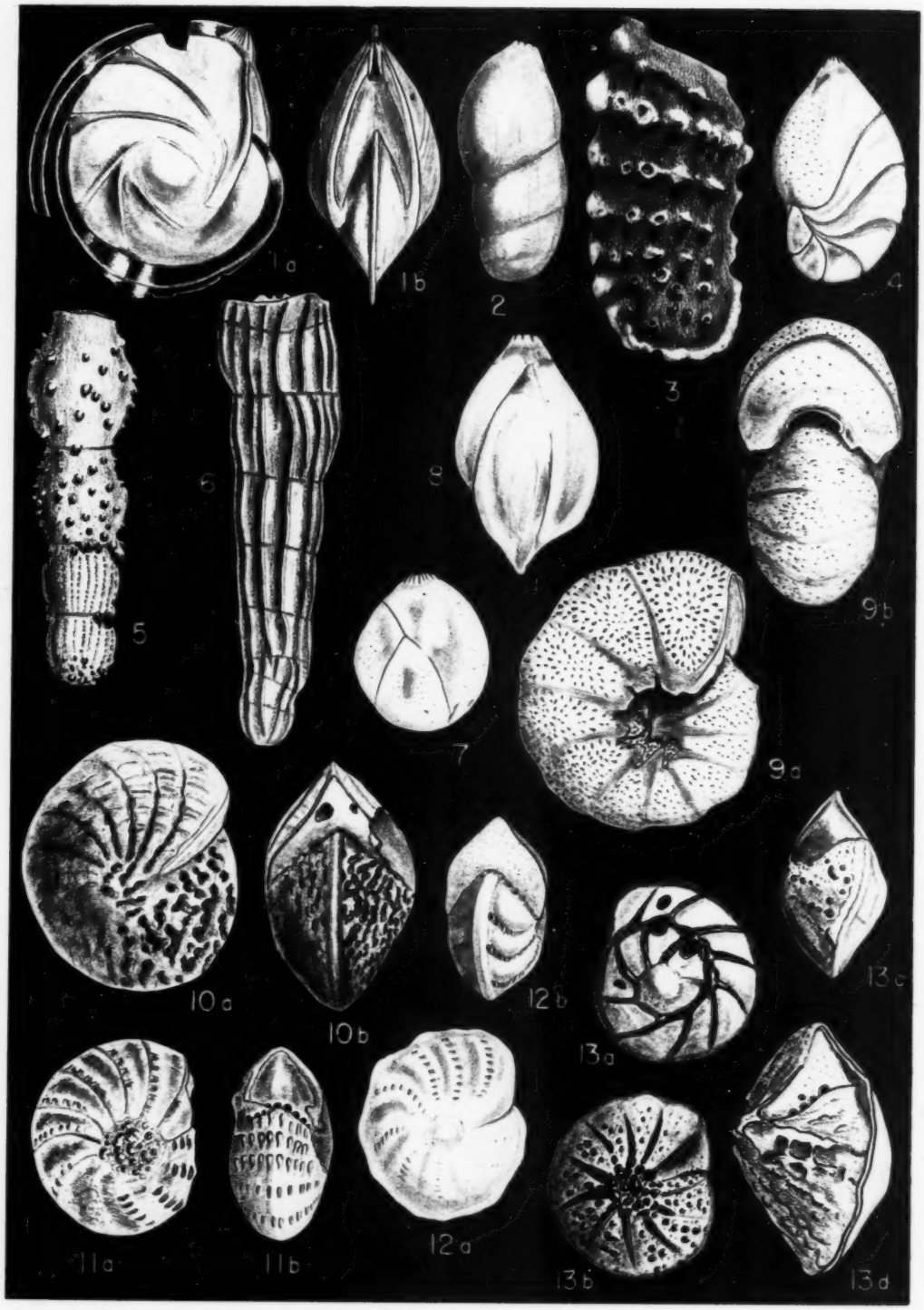
EXPLANATION OF PLATE 36

FIG. *1—Textularia zeaggluta* Finlay. ×70. Juvenile. (p. 286)
2—Textularia aorangi Dorreen, n. sp. ×70. a, side view; b, basal view, holotype. (p. 286)
3—Gaudryina minuscula ? Finlay. ×70. a, side view; b, apertural view and side view. (p. 286)
4—Karreriella novozealandica Cushman. ×45. a, side view; b, peripheral view; c, ×70, peripheral view, juvenile. (p. 286)
5—Arenodosaria kaiataensis Dorreen, n. sp. ×45. Holotype. (p. 287)
6—Quinqueloculina sp. aff. *plana* d'Orbigny. ×70. a, side view; b, apertural view. (p. 287)
7—Quinqueloculina striata d'Orbigny. ×70. a, side view; b, apertural view. (p. 287)
8—Flintina novozealandica Dorreen, n. sp. ×70. a, side view-spiroloculine stage, holotype; b, apertural view-triloculine stage, paratype. (p. 287)
9—Hauerina notoensis Dorreen, n. sp. ×45. a, lateral view; b, apertural view, holotype; c, ×70, apertural view, paratype; d, ×70, longitudinal section showing quinqueloculine early chambers. (p. 287)



Dorreen, New Zealand Eocene Foraminifera



Dorreen, New Zealand Eocene Foraminifera

by globose chambers separated by thin necks. *N. hirsuta* var. *sublineata* occurs in typical form in the Mahoenui beds of Taranaki, but does not appear to be closely related to this species.

Dimensions: Length 0.80 mm., width .25 mm.

Common.

NODOSARIA cf. CRASSITESTA Schwager
Plate 37, figure 6

Nodosaria crassitesta SCHWAGER, 1866, Novara Exped., Geol. Theil, vol. 2, pt. 2, p. 224, pl. 5, fig. 55.

A *Nodosaria* somewhat like *N. crassitesta* Schwager occurs commonly in this fauna. All specimens were broken so no description is attempted.

Dimensions: Length 0.90 mm., width 0.25 mm.

Common.

NODOSARIA LONGISCATA d'Orbigny

Nodosaria longiscata D'ORBIGNY, 1846, Foraminiféres fossiles du bassin Tertiaire de Vienne (Autriche), p. 32, pl. 1, figs. 10, 11, 12.

This species, described from the Tertiary of the Vienna Basin, occurs commonly and ranges throughout the New Zealand Tertiary formations.

Genus SARACENARIA Defrance 1824
SARACENARIA KELLUMI Dorreen, n. sp.
Plate 37, figure 4

Test small; wall thin, glassy in well preserved specimens; most of test closely coiled; last chamber evolute, pyramidal, two penultimate chambers showing evolute tendency; subangular peripheral keel right to aperture; last chamber triangular in transverse section with triangular, gently convex ventral face; later sutures sinuous; aperture simple, terminal, round, with radiating striae, and a median ventral slit.

Dimensions of holotype: Height 0.50 mm., width 0.25 mm.

Frequent.

Family POLYMORPHINIDAE
Subfamily POLYMORPHININAE
Genus GUTTULINA d'Orbigny, 1839
GUTTULINA sps.
Plate 37, figure 8

Two species of *Guttulina* are common.

Genus GLOBULINA d'Orbigny, 1839
POLYMORPHINA (GLOBULINA) GIBBA d'Orbigny
Plate 37, figure 7

"Globulines, Les," D'ORBIGNY, 1826, Ann. Sci. Nat., vol. 7, p. 266.
Globulina, D'ORBIGNY in De la Sagra, 1839, Hist. Phys. Pol. Nat. Cuba, Foraminiféres, p. 134.

Occurs rarely.

Family NONIONIDAE
Genus NONION Montfort, 1808
NONION MAORICUM (Stache)
Plate 37, figures 9a, 9b

Rosalina maorica STACHE, 1864, Novara Exped., Geol. Theil, vol. 1, p. 282, pl. 24, fig. 32 a, c.
Nonion maoricum (Stache) FINLAY, 1940, Trans. Roy. Soc. New Zealand, vol. 69, pt. 4, p. 451.

Planispiral, early chambers completely involute, later ones showing evolute ten-

EXPLANATION OF PLATE 37

FIG. *1—Robulus gyroscalprum* (Stache). ×70. a, side view; b, peripheral view. (p. 288)
2—Marginulina subbullata Hantken. ×70. (p. 288)
3—Marginulina hochstetteri Stache. ×70. (p. 288)
4—Saracenaria kellumi Dorreen, n. sp. ×70. holotype. (p. 289)
5—Nodosaria cf. *hispida* var. *agglutinans* Perner. ×70. (p. 288)
6—Nodosaria cf. *crassitesta* Schwager. ×70. (p. 289)
7—Globulina gibba d'Orbigny. ×70. (p. 289)
8—Guttulina sp. ×70. (p. 289)
9—Nonion maoricum (Stache). ×70, a, side view; b, peripheral view. (p. 289)
10—Elphidium ingressans Dorreen, n. sp. ×70. a, side view; b, peripheral view, holotype. (p. 290)
11—Elphidium nitidum Dorreen, n. sp. ×70. a, side view: b, peripheral view, holotype. (p. 290)
12—Elphidium omotoensis Dorreen, n. sp. ×70. a, side view; b, peripheral view, holotype. (p. 290)
13—Notorotalia tainuia Dorreen, n. sp. ×70. a, dorsal view; b, ventral view; c, peripheral view (all 3 views of holotype); d, peripheral view of broken specimen showing foramina. (p. 290)

dency, leaving umbilical area marked by inward projections from the sutures; chambers somewhat compressed, all but last one or two higher than wide, periphery rounded; sutures broad, slightly sunken; in clear specimens test ornamented by prominent pores; aperture a broad low arch at base of septal face.

Dimensions: Greatest diameter 0.60 mm., width 0.35 mm.

Occurs commonly; ranges into the Whaingaroan.

Genus ELPHIDIUM Montfort, 1808

ELPHIDIUM INGRESSANS Dorreen, n. sp.
Plate 37, figures 10a, 10b

Planispiral, involute, discoidal; test of stout construction; sutures limbate, ornamented with irregular granules, which in the early portion of the last whorl are coalesced in groups obscuring the sutures entirely, granules continue over the umbilical area; retral processes slightly limbate, extending between sutures; aperture indistinct, possibly closed; periphery with low subangular keel.

Dimensions of holotype: Greatest diameter 0.55 mm., width .30 mm.

Frequent.

ELPHIDIUM NITIDUM Dorreen, n. sp.
Plate 37, figures 11a, 11b

Planispiral involute; wall of test much thinner than that of *E. ingressans;* sutures flush with test, slightly retroflexed; retral processes short, set in very shallow radial depressions; umbilical area obscure, ornamented with low granules; aperture a well developed row of openings at base of terminal face; periphery rounded, without keel.

Dimensions of holotype: Greatest diameter 0.40 mm., width 0.20 mm.

Uncommon.

ELPHIDIUM OMOTOENSIS Dorreen, n. sp.
Plate 37, figures 12a, 12b

Planispiral, involute, discoidal; sutures limbate, straight for part of their length, then retroflexed as they approach the periphery; retral processes short, in groove between sutures; umbilical area with varying amount of smooth shell material; aperture indistinct; periphery with blunt keel.

Dimensions of holotype: Greatest diameter 0.40 mm., width 0.20 mm.

Common.

Genus NOTOROTALIA Finlay, 1939

NOTOROTALIA TAINUIA Dorreen, n. sp.
Plate 37, figures 13a–13d

Test trochoid, biconvex, low spire of two to three whorls, 10 chambers in last whorl; dorsal surface with nacreous lustre, dorsal sutures limbate, distinct, radial ones bent back at about 40° to spiral; ventral surface granulated with prominent cluster of granules in umbilical area, earlier ventral sutures somewhat obscured, later ones limbate and granulated, slightly retroflexed; no aperture in perfect specimens; foramina a row of small openings, as in *Elphidium*, but occurring at base of septal face at its contact with ven-

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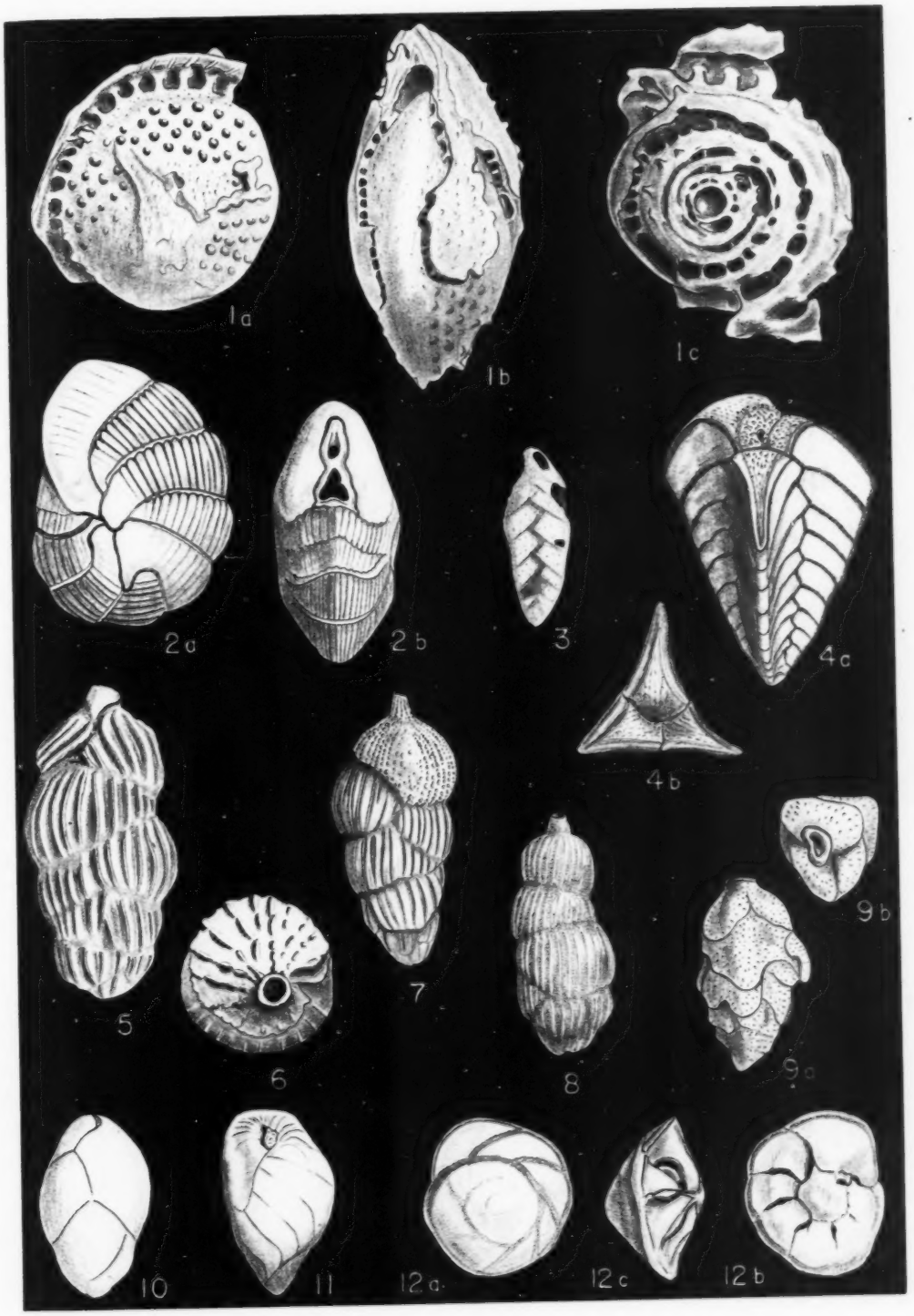
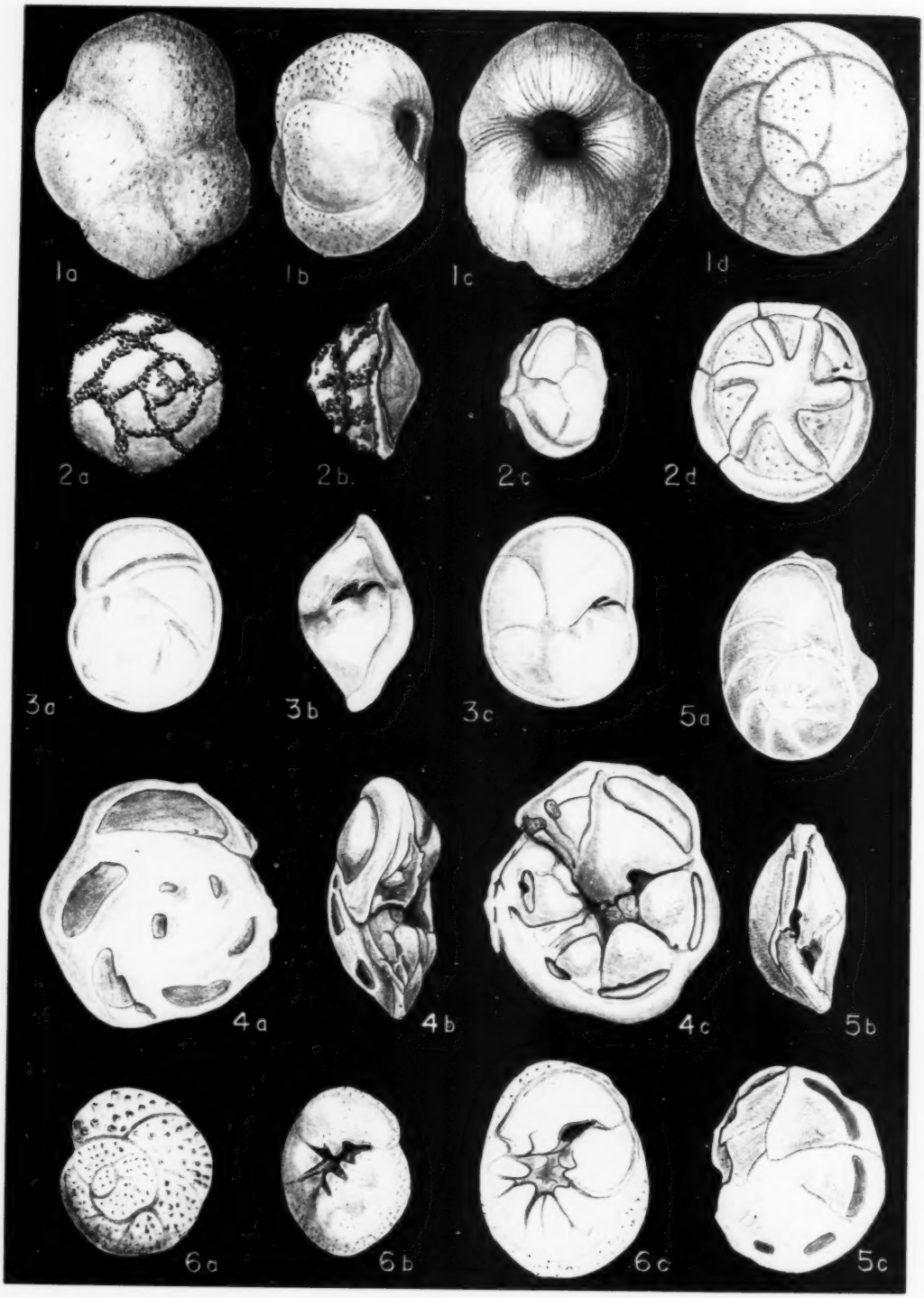
EXPLANATION OF PLATE 38

All figures ×70 unless otherwise indicated.

FIG. *1*—*Nummulitella polystylata* Dorreen, n. sp. a, side view of genoholotype; b, peripheral view of paratype; c, longitudinal section of paratype. (p. 291)
2—*Peneroplis mauii* Dorreen, n. sp. a, side view; b, peripheral view. Holotype. (p. 291)
3—*Bolivina* sp. (p. 292)
4—*Reussella finlayi* Dorreen, n. sp. a, side view; b, apertural view. Holotype. (p. 292)
5—*Uvigerina bortotara* (Finlay) var. *costata* Dorreen, n. var. Holotype. (pl 293)
6—*Uvigerina bortotara* (Finlay). Note siphon visible inside aperture. (p. 292)
7—*Uvigerina pigmea* d'Orbigny. From Italian Pliocene. (p. 292)
8—*Reciuvigerina prisca* (Finlay). (p. 293)
9—*Angulogerina elliptica* Dorreen, n. sp. a, side view; b, apertural view. Holotype. (p. 293)
10—*Bulimina pupula* Stache. ×45. (p. 292)
11—*Buliminella* cf. *turbinata* (Terquem). (p. 292)
12—*Discorbis finlayi* Dorreen, n. sp. a, dorsal view; b, ventral view showing central boss and sutural apertures (both views of sinistrally coiled holotype); c, peripheral view of paratype showing two foramina in septal face and ridges on septa of broken chambers, dextrally coiled. (p. 293)



Dorreen, New Zealand Eocene Foraminifera



Dorreen, New Zealand Eocene Foraminifera

tral surface of the preceding whorl; retral processes left as ridges on the ventral surface of broken specimens.

Dimensions of holotype: Greatest diameter 0.40 mm., width 0.25 mm. Abundant.

This species differs from the genotype of *Notorotalia* in possessing a smooth dorsal surface and a granular, instead of reticulate, ventral side. However, retral processes can be observed on the ventral side, especially in broken specimens and, as in apertural characteristics, it agrees with *Notorotalia*, I believe it should be placed in this genus.

Family NUMMULITIDAE
Genus NUMMULITELLA, Dorreen, n. gen.
Genotype: NUMMULITELLA POLYSTYLATA Dorreen, n. sp.

Test calcareous, planispiral, involute, discoidal; wall thin, rows of pillars replacing septa of other genera of this family, pillars arranged in regular pattern.

NUMMULITELLA POLYSTYLATA
Dorreen, n. sp.
Plate 38, figures 1a–1c

Planispiral, involute, discoidal, whorls compressed; test fragile, ends of pillars observable through test; rows of pillars, increasing in height from umbilical to peripheral areas, represent septa; these make a geometric pattern on the test, the pillars being situated on corners of equilateral triangles; apertures numerous along base of septal face somewhat like those of *Elphidium*; main aperture an arched opening at base of septal face at periphery; interior without distinct chambers, except possibly in early portion.

Dimensions of genoholotype: Greatest diameter 0.70 mm., width 0.35 mm.

This species occurs abundantly in this fauna, but has not been seen elsewhere.

Family PENEROPLIDAE
Subfamily SPIROLININAE
Genus PENEROPLIS Montfort, 1808
PENEROPLIS MAUII Dorreen, n. sp.
Plate 38, figures 2a, 2b

Test planispiral, moderately compressed, involute in young, showing tendency to uncoil and become flared in adult; chambers with concentric flutings characteristic of genus; aperture in young simple, at base of septal face, surrounded by white shelly border, not raised; with increasing flaring this simple aperture elongates into a triangle and finally another aperture splits off; this process may be repeated until a row of apertures results.

Dimensions of holotype: Greatest diameter 0.60 mm., width 0.30 mm.

The figured specimen is representative of an average adult. However, one broken fragment indicated that the species can develop a very flaring ultimate chamber with about seven apertures. This species is unlike any described to date. It occurs commonly in this fauna and has not been noted elsewhere.

EXPLANATION OF PLATE 39
All figures ×70

FIG. *1*—*Glabratella crassa* Dorreen, n. sp. a, dorsal view; b, side view; c, ventral view (all 3 views of genoholotype); d, dorsal view to show range of variation of species—ventral view of this specimen exactly like *1* c. (p. 294)

2—*Eponides dorsopustulatus* Dorreen, n. sp. a, dorsal view; b, side view; c, ¾ ventral view (all 3 views of dextrally coiled holotype); d, ventral view of sinistrally coiled paratype—appearance when coated with oil of cloves. (p. 295)

3—*Eponides tethycus* Dorreen, n. sp. a, dorsal view; b, peripheral view; c, ventral view. Holotype. (p. 295)

4—*Stomatorbina torrei* (Cushman and Bermudez). a, dorsal view. Sutures in this specimen are more thickened than usual; b, peripheral view; c, ventral view, last chamber broken away. (p. 296)

5—*Stomatorbina* sp. a, dorsal view; b, peripheral view; c, ventral view. (p. 296)

6—*Lamarckina turgida* Dorreen, n. sp. a, dorsal view; b, ¾ ventral view (both views of holotype); c, broken specimen showing foramen. (p. 297)

Family BULIMINIDAE
Subfamily TURRILININAE
Genus BULIMINELLA
BULIMINELLA cf. TURBINATA
(Terquem)
Plate 38, figure 11

Bulimina turbinata TERQUEM, 1882, Mem. Soc. Géol. France, ser. 3, vol. 2, p. 113, pl. 12 (20), figs. 6, 7.
Buliminella turbinata (Terquem) CUSHMAN, 1937, Cushman Lab. Foram. Research Contr., vol. 13, pt. 3, p. 68, pl. 9, figs. 8, 9.

A *Buliminella*, evidently very close to *B. turbinata*, described from the lower Calcaire grossier of Vaudancourt, occurs frequently.

Subfamily BULIMININAE
Genus BULIMINA d'Orbigny, 1826
BULIMINA PUPULA Stache
Plate 38, figure 10

Bulimina pupula STACHE, 1864, Novara Exped., Geol. Theil, vol. 1, p. 265, pl. 24, fig. 13.

This form is closely allied to *B. pupoides* d'Orbigny. No topotypes of *pupoides* were available for study. Cushman (1937), however, mentions that *pupula* is larger, with less inflated chambers and a thicker wall. Occurs rarely.

Subfamily VIRGULININAE
Genus BOLIVINA d'Orbigny, 1839
BOLIVINA sp.
Plate 38, figure 3

A fragment of a specimen apparently allied to *B. lapsus* Finlay was found. Although the *lapsus* line was not thought to commence as early in the Tertiary, the fragment shows relationship to this lineage.

Subfamily REUSSELLINAE
Genus REUSSELLA Galloway, 1933
REUSSELLA FINLAYI Dorreen, n. sp.
Plate 38, figures 4a, 4b

Test triserial, triangular in transverse section, greatest breadth at apertural end, ratio of this breadth to height—3:4; three longitudinal carinae placed at 120° to each other run longitudinally, diverging at about 40°; chambers triangular in cross section and the locus of the apex of each series forms a longitudinal carina; between the three carinae the test is evenly concave; sutures flush with surface; apertural end conspicuously perforate, slightly granular around aperture, which is a small crescentic opening at the base of the last formed chamber.

Dimensions of holotype: Length 0.60 mm. width 0.45 mm.

Abundant.

This species does not compare closely with any hitherto described species. It is larger than *R. spinulosa* and is a less ornate species. A few specimens with broken apertural ends apparently exhibit a tendency to develop a terminal chamber immediately following the triserial stage.

Subfamily UVIGERININAE
Genus UVIGERINA d'Orbigny, 1826
UVIGERINA BORTOTARA (Finlay)
Plate 38, figure 6

Hopkinsina bortotara FINLAY, 1939, Trans. Roy. Soc. New Zealand, vol. 69, pt. 1, p. 104, pl. 12, figs. 22–24.

The reference of this common Bortonian-Kaiatan species to *Hopkinsina* does not appear justifiable. Finlay comments that this species is unlike *H. danvillensis*, the genotype. I consider that for a species to be referred to *Hopkinsina* it must have a closely knit twisted biserial stage; yet this stage should resemble *Bolivina* and not simply exhibit a loosely biserial tendency. A second point is the aperture, which in *H. danvillensis* is little more than a circular lip, the neck being practically missing. In *Uvigerina* the distinctive neck has been stressed by d'Orbigny.

A free translation of d'Orbigny's description of *Uvigerina pigmea*, designated as the genotype by Parker and Jones, 1863, reads as follows:

"High spired, unattached test. Elongate spire continued through all growth stages; chambers very globose; aperture central, terminal, at the tip of a prolongation from the last chamber."

Mr. Benton Stone kindly lent me some topotypes of *U. pigmea* from the Pliocene of Coroncina, near Sienna, Italy. I have figured one of these specimens (Plate 38, figure 7) and in the last four chambers can be seen the same loose, twisted, biserial arrangement that characterizes the proximal chambers of *Uvigerina bortotara*.

Attention is drawn to the figure showing the apertural view of *U. bortotara* (Plate 38,

figure 6) in which the mouth of the siphon can be seen inside the aperture. This appears to be a readily observable feature of some of the Buliminidae (Stone, 1946) but has rarely been figured.

UVIGERINA BORTOTARA (Finlay)
var. COSTATA Dorreen, n. var.
Plate 38, figure 5

This variety is similar in all respects to *U. bortotara*, except that there are no anterior prickles, the axial ribs being continued over the last chamber to the base of the apertural neck. The *costata* variety is more common in this fauna than *U. bortotara* and has also been noted from the Te Hua marls (Bortonian) of Poverty Bay. An almost identical form occurs in the Miocene of Kostej-Valea Semini, Rumania.

Dimensions of holotype: Length 0.65 mm., width 0.40 mm.

Common.

Genus RECTUVIGERINA
Mathews, 1946
RECTUVIGERINA PRISCA (Finlay)
Plate 38, figure 8

Siphogenerina prisca FINLAY, 1939, Trans. Roy. Soc. New Zealand, vol. 69, pt. 1, p. 110, pl. 13, figs. 48–51.
Rectuvigerina prisca (Finlay) MATHEWS, 1946, Journ. Pal., vol. 19, no. 6, p. 595, pl. 81, fig. 19.

This is the first record of this species in a fauna of other than Upper Bortonian age. It indicates faunal relationship between the two stages and affords further evidence for assigning the Kaiatan to the Upper Eocene.

Genus ANGULOGERINA Cushman, 1927
ANGULOGERINA ELLIPTICA
Dorreen, n. sp.
Plate 38, figures 9a, 9b

Test about twice as long as broad, triangular in transverse section; chambers large, irregular in shape, due to broad posteriorly projecting lobes, which overlap onto chambers of previous whorl, wall material translucent in well preserved specimens, conspicuously perforate; the three axial ridges, at 120° to each other, rounded; aperture terminal, with a low surrounding lip, kidney shaped when viewed from above.

Dimensions of holotype: Length 0.40 mm., width 0.25 mm.

Frequent.

This form shows similarities to *A. europea* Cushman and Edwards, of which species Dr. Cushman kindly supplied topotypes for comparison. It also compares with *A. rugoplicata* Cushman. It occurs frequently in the Kaiatan of Jackson's Paddock, Oamaru.

Family ROTALIIDAE
Subfamily DISCORBINAE
Genus DISCORBIS Lamarck, 1804
DISCORBIS GALERUS Finlay

Discorbis galerus FINLAY, 1940, Trans. Roy. Soc. New Zealand, vol. 69, pt. 4, p. 466.

Finlay notes the occurrence of this species in the Hutchinsonian of Pakaurangi Point and also in the Waitakian. However, it is present in this fauna, possessing exactly the differences from *D. scopos* which were described by Finlay, e.g. gently concave base and smaller proloculum.

Diameter.—1 mm.

Rare.

DISCORBIS FINLAYI Dorreen, n. sp.
Plate 38, figures 12a–12c

It is with some hesitation that I place this species in *Discorbis*. However, without a study of the genotype, *D. vesicularis*, it is obviously inadvisable to erect a new genus.

Test medium to coarsely perforate, biconvex, dorsally more so than ventrally; low trochoid spire with five to seven chambers to a whorl; all whorls visible dorsally, only the last one ventrally; dorsal sutures broad, generally flush with surface. Periphery with sharp radially striated, overhanging keel; aperture a low arch at contact of base of last chamber and preceding whorl; face of penultimate chamber reveals two foramina both of which open into the aperture; the upper a reniform slit which runs outward from contact of septal face and preceding whorl and then curves back, concave towards previous whorl; a groove connects this slit to a smaller round ventral foramen, which opens into an annular canal encircling or underlying a shelly plug, which can be seen as a low boss in the centre of the ventral surface; this boss appears to have been formed by fusion of the inner edges of the chamber walls; deep slits along the septa of the ventral face open into the annular canal,

which communicates by means of the secondary foramen with the aperture; between the primary foramen and the preceding whorl, there is a thickening of shell material which appears to represent the shelf noted by Plummer (1940) in the structure of *Ceratobulimina;* as the chambers become broken away a series of these thickened "shelves" are left standing as ridges along the sutures.

Dimensions of holotype: Greatest diameter 0.35 mm., thickness 0.20 mm.

Holotype from Mahoenui mudstone, above road tunnel, east entrance to Awakino Gorge, Taranaki.

Very common.

This form appears to have close relatives in *Discorbis mira* Cushman from the Recent off Florida, and in the Cuban Eocene. *Discorbis finlayi* is present in the Middle Eocene Eyre River Chalk, in the Kaiatan Oamaru Limestone from Jackson's Paddock and in the Upper Oligocene Mahoenui Beds of Taranaki. A close relative is present in the Calcaire grossier of the Paris Basin. Terquem must have described the French form, but several of his idealized figures could answer the requirements.

Genus GLABRATELLA, Dorreen, n. gen.
Genotype GLABRATELLA CRASSA Dorreen, n. sp.

This genus seems to have arisen from *Discorbis* by a ventral migration of the aperture until it is a simple round opening in the centre of the ventral face. Test inflated, a trochoid spire of few whorls; chambers globose; dorsal surface slightly roughened to ornamented; ventral surface smooth, with fine radial striae.

Other species of *Glabratella* are: *G. pulvinata* (Brady), *G. cristata* (H.–Q. and E.), *G. globigeriniformis* (H.–Q. and E.). *G. inflata* (H.–A. and E.) and *G. cruciformis* (Howchin). The genus is thus recorded from New Zealand (Eocene), Australia (Miocene) and from the Recent of Admiralty Islands, Kerimba Archipelago, Mediterranean, and England. *G. pulvinata* is also present in the Pliocene Charco Azul formation of Panama.

GLABRATELLA CRASSA Dorreen, n. sp.
Plate 39, figures 1a–1d

Test globose, a low trochoid spire; smooth ventral surface, dorsal surface medium to coarsely perforate and covered with fine granules; granular inflated chambers tend to conceal the dorsal sutures which, when the chambers are very globose may be depressed in shallow grooves, or may be seen in other specimens flush with surface; with aperture a round opening in a depression in the centre of the ventral face. From the aperture fine lines radiate outward.

Dimensions of genoholotype: Greatest diameter 0.55 mm., thickness 0.35 mm.

Frequent.

G. crassa undergoes considerable variation. It occurs abundantly in the Eyre River Chalks, but all the Eyre River specimens are smaller than those in the Kaiatan.

Genus GYROIDINA d'Orbigny, 1826
GYROIDINA ZELANDICA Finlay

Gyroidina zelandica FINLAY, 1939, Trans. Roy. Soc. New Zealand, vol. 69, pt. 3, p. 323, pl. 28, figs. 138–140.

In his description Finlay mentions that this species has a probable range of Kaiatan to Opoitian (Pliocene).

It occurs frequently in this fauna.

EXPLANATION OF PLATE 40

All figures ×70 unless otherwise indicated.

FIG. *1—Lamarckina novozealandica* Dorreen, n. sp. a, dorsal view; b, peripheral view; c, ventral view (all 3 views of holotype); d, broken specimen showing foramen. (p. 297)

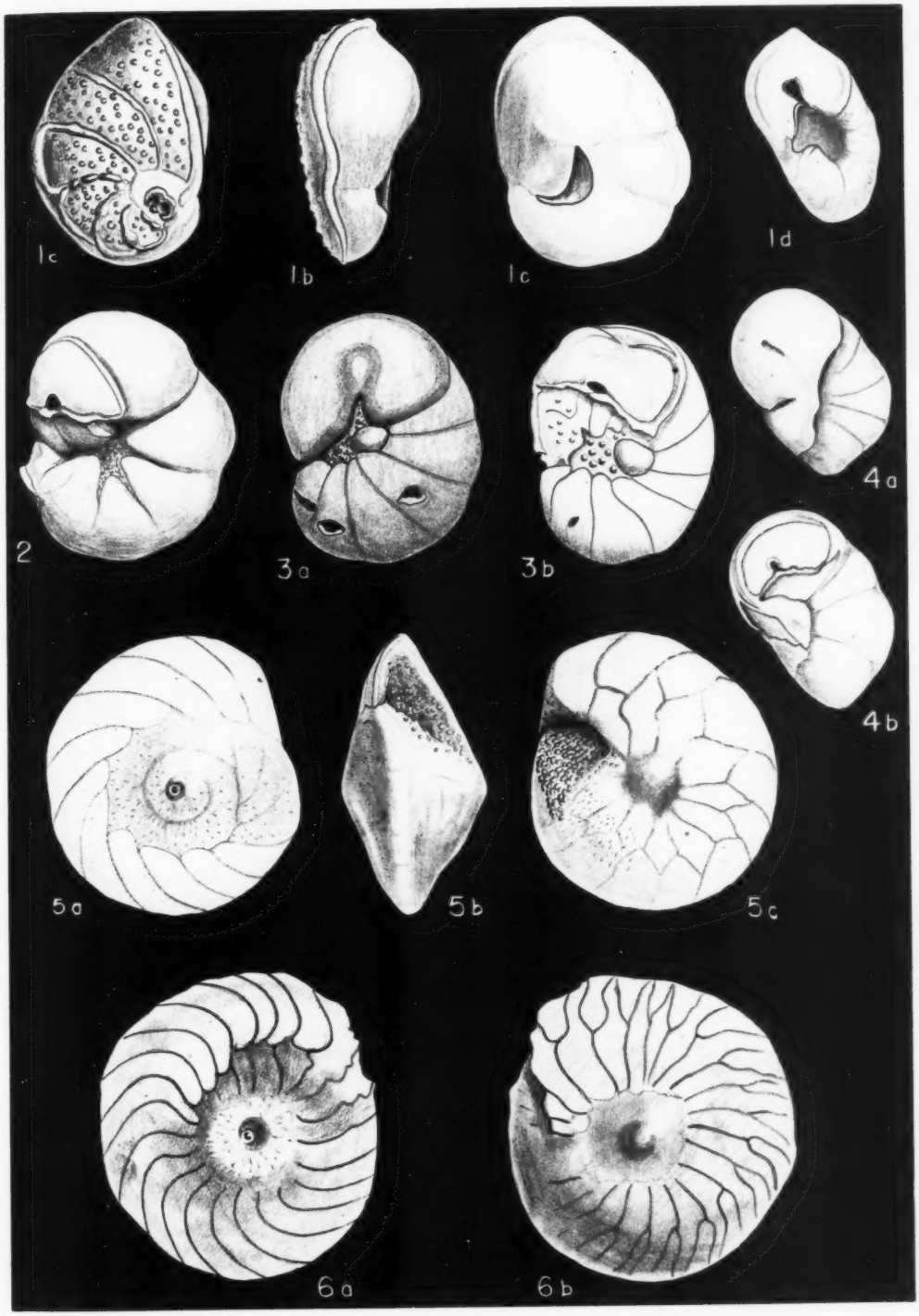
2—Ceratobulimina lornensis Finlay. Ventral view of broken specimen showing foramen. (p. 297)

3—Cerobertina kakahoica Finlay. a, ventral view; b, ventral view of broken specimen showing foramen. (p. 297)

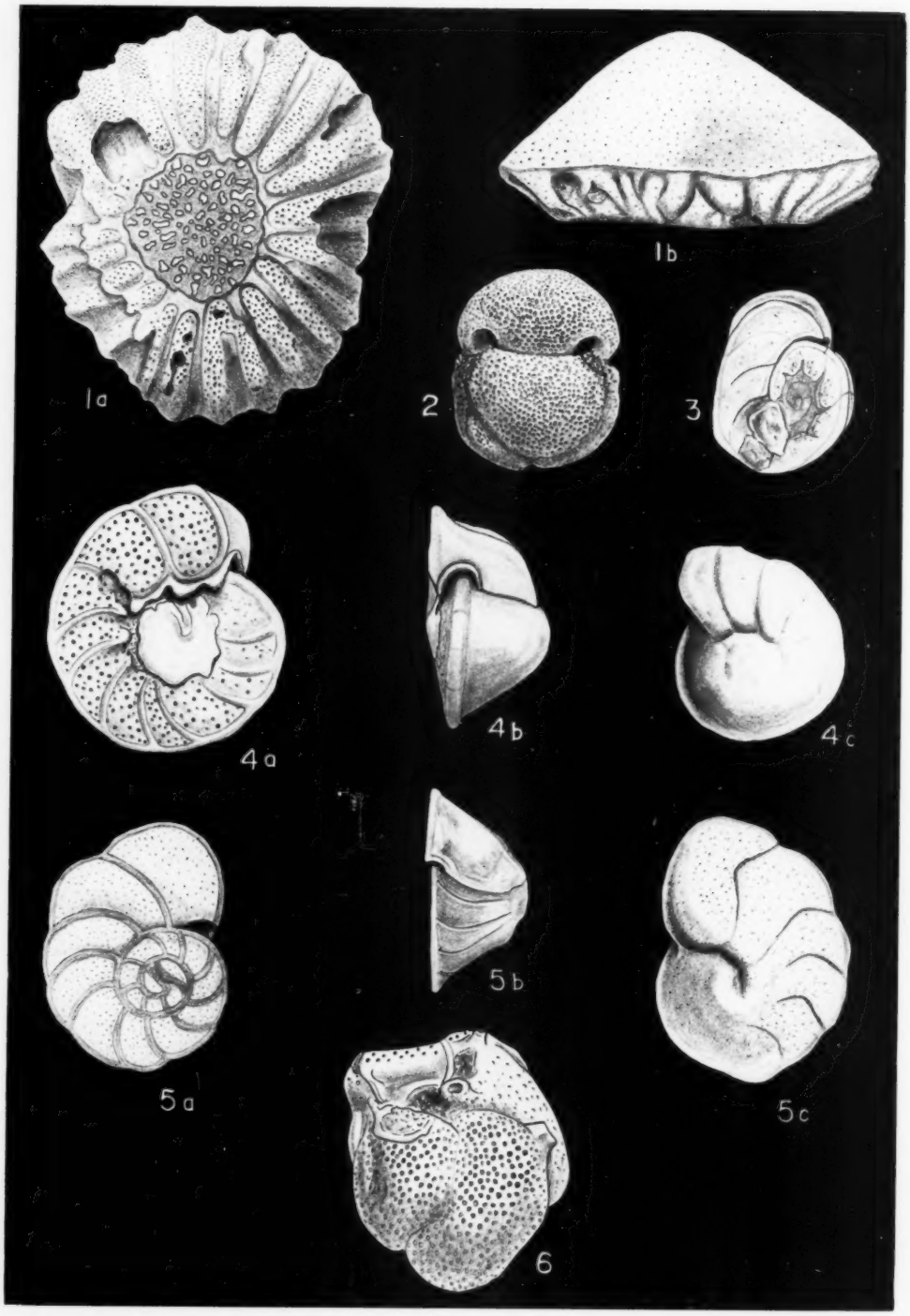
4—Robertina lornensis Finlay, a ventral view; b, ventral view of broken specimen showing foramen. (p. 297)

5—Asterigerina cyclops Dorreen, n. sp. a, dorsal view; b, peripheral view; c, ventral view. Holotype. (p. 297)

6—Amphistegina sp. ×45. a, dorsal view; b, ventral view. (p. 298)



Dorreen, New Zealand Eocene Foraminifera



Dorreen, New Zealand Eocene Foraminifera

Subfamily ROTALIINAE
Genus EPONIDES Montfort, 1808
EPONIDES DORSOPUSTULATUS
Dorreen, n. sp.
Plate 39, figures 2a–2d

Test trochoid, planoconvex, dorsally high spired, dome shaped, consisting of 2 whorls; ventral side nearly flat or gently convex; six chambers in last whorl; periphery with low rounded keel which is seen as a rim around the ventral surface; dorsal sutures limbate and heavily ornamented with granules; ventral surface smooth, with a thickening of extra shell material; ventral sutures may be set in slightly depressed grooves, or, more commonly, broad and slightly limbate, gently retroflexed; aperture usually very hard to see, a short narrow curved slit at base of the last chamber, commencing just inside the peripheral keel.

Dimensions of holotype: Diameter 0.30 mm., height 0.25 mm.

Abundant.

This foraminifer, which has not been seen elsewhere is difficult to place generically. In general shape it is similar to *Eponides procerus* (Brady) although it shows closer affinities to *Eponides principiensis* Cushman and Bermudez from the Eocene of Cuba.

EPONIDES TETHYCUS Dorreen, n. sp.
Plate 39, figures 3a–3c

Test biconvex, ventrally more inflated than dorsally, rounded keel encircling periphery, fifth to sixth chambers to adult whorl; sutures flush to slightly limbate on the dorsal side, earlier sutures obscure, usually only three or four clearly seen, ventral sutures somewhat depressed, earlier ones covered by smooth coating of shell material; entire surface smooth and polished; aperture ventral, interio-marginal, readily divisible into an upper and a lower part separated by a constriction; lower part of aperture an elongate V with apex directed ventrally, upper part slit, crescent, or mushroom shaped.

Dimensions of holotype: Greatest diameter 0.40 mm., thickness 0.25 mm.

Holotype from Mahoenui Mudstone, above road tunnel, east entrance to Awakino Gorge, Taranaki.

Occurs rarely in this fauna.

An interesting occurrence of this species is in the Lower Oligocene Kis Czell shale of Budapest. The Hungarian species agrees in every respect with the New Zealand one. I have not had access to any of von Hantken's papers and am unable to discover whether he described this form. An extremely similar form occurs in the Rumanian Miocene.

It occurs in the Kaiatan and the Mahoenui beds of Taranaki.

Subfamily SIPHONININAE
Genus EPISTOMINA Terquem, 1883
EPISTOMINA ELEGANS (d'Orbigny)

Rotalia (*Turbinulina*) *elegans* D'ORBIGNY, 1826, Ann. Sci. Nat., vol. 7, p. 276, no. 54.
Epistomina elegans (d'Orbigny) CUSHMAN, 1927, Cushman Lab. Foram. Research Contr., vol. 3, pt. 4, p. 182, pls. 31 and 32.

Occurs commonly in this fauna and throughout the New Zealand Tertiary.

Genus STOMATORBINA Dorreen, n. gen.
Genotype STOMATORBINA TORREI
(Cushman and Bermudez)

Lamarckina torrei CUSHMAN and BERMUDEZ, 1937, Further New Species of Foraminifera from the Eocene of Cuba, Cushman Lab. Foram. Research Contr., vol. 13, pt. 1, p. 21, pl. 2, figs. 24–26.

Low trochoid spire, dorsal sutures broad and limbate; ventral sutures sharp and depressed; periphery usually subacute; aperture ventral, an elongate slit at base of last chamber; supplementary apertures, or clear

EXPLANATION OF PLATE 41
All figures ×70

FIG. *1—Halkyardia bartrumi* Parr. a, ventral view; b, side view. (p. 298)
2—Globigerinoides index Finlay. (p. 298)
3—Cibicides pseudoconvexus Parr. n. var. (p. 299)
4—Cibicides perforatus (Karrer) var. *notocenicus* Dorreen, n. var. a, dorsal view of holotype; b, peripheral view of paratype; c, ventral view. (p. 299)
5—Cibicides vortex Dorreen, n. sp. a, dorsal view of holotype; b, peripheral view of paratype; c, ventral view of holotype. (p. 299)
6—Carpenteria aff. *bulloides* Galloway and Heminway. (p. 299)

spaces, on ventral side of each chamber, just below periphery, elongated spirally, depressed below surrounding surface and closed by smooth shell material, usually of slightly different colour from that of the rest of the ventral surface.

STOMATORBINA TORREI (Cushman and Bermudez)
Plate 39, figures 4a–4c

In their description of *S. torrei*, Cushman and Bermudez do not mention the supplementary apertures, which are hard to see in some poorly preserved specimens.

The species may be redescribed as follows:

Test plano-convex, dorsal side with low rounded spire, ventral side flattened to gently inflated; five to six chambers in adult whorl, periphery subacute with a rounded keel, strongly raised on the dorsal side, ventrally ending in a point at the inner end; dorsal sutures limbate and strongly curved, ventral sutures straight, radiate and slightly depressed; wall of the dorsal side with periphery and sutures strongly raised and in the central area further thickened to obscure the earlier chambers; aperture a low opening at the ventral border of the last formed chamber, each chamber with a supplementary aperture or clear space on the ventral side just below the periphery; these supplementary apertures are depressed, covered with shell material, and are spirally elongated.

Dimensions: Length 1.30–1.65 mm. width 1.10–1.45 mm., thickness 0.60–0.75 mm.

As *Eponides concentricus* (or *Pulvinulina concentrica*) this, or closely allied species, have been recorded from the tropical Pacific, the Indo Pacific, Australia, the Kerimba Archipelago and the Mediterranean by various authors. I am indebted to Mrs. Plummer for supplying me with Recent specimens from the Shetlands, which possess limbate dorsal sutures, but also *Eponides*-like apertures without supplementary apertures and which are not related to *Pulvinulina concentrica* as figured by Brady in the Challenger Report (Plate CV, figures 1a and b). Hence it is apparent that two different genera have been called *Pulvinulina concentrica* Parker and Jones. Although the one figured in the Challenger Report seems to have been adopted as typical by most subsequent authors, yet, obviously, confusion exists and *S. torrei* is here adopted as the genotype. I am indebted to Mr. B. Stone for drawing my attention to *S. torrei*.

Another genus which must be considered here is *Mississippina*. Chapman (1941) records *Mississippina concentrica* from the Philippines, from South of Cape Wiles, and from the Lower Miocene of Port Phillip. Parr (1943) records *Eponides concentricus* from the Victorian Coast and states that the characters of the species suggest that it might be referred to *Mississippina*. Dr. Howe kindly sent specimens of his *Mississippina monsouri*, the ventral face of which shows great similarity to the ventral face of *Stomatorbina*. However, in *Mississippina* the whorls embrace both dorsally and ventrally and the aperture extends from the ventral side, across the periphery, to the dorsal side. Dorsal sutures are not limbate, as in *Stomatorbina*, but are depressed and the supplementary apertures are on both dorsal and ventral surfaces. Therefore, while I cannot accept *Mississippina* and *Stomatorbina* as being congeneric, the two are clearly related and I suggest that *Mississippina* has arisen as an offshoot from *Stomatorbina*.

Stomatorbina torrei occurs frequently in this fauna and occurs also in the Eyre River *Discocyclina* Chalk, the Kaiatan Limestone of Jackson's Paddock and the Mahoenui Beds of Taranaki.

STOMATORBINA sp.
Plate 39, figure 5

Two broken specimens were found, which, as far as can be seen, have all the characteristics of *Stomatorbina*. The chambers increase in size more rapidly than in *S. torrei;* dorsal sutures are slightly limbate and the ventral supplementary apertures are clearly defined. No description is attempted, as the apertures are broken in both specimens.

Dimensions: Greatest diameter 0.45 mm., thickness 0.20 mm.

Very rare.

Family CERATOBULIMINIDAE
Glaessner, 1937
Genus LAMARCKINA Berthelin, 1881
LAMARCKINA TURGIDA
Dorreen, n. sp.
Plate 39 figures 6a–6c

Test trochoid, biconvex, periphery rounded; dorsal side coarsely perforate, ventral side finely perforate, smooth; six to seven chambers to adult whorl; tongue shaped prolongations, one from each chamber, project into the umbilicus; aperture a long irregular opening between inner margin of terminal face and the umbilicus; where final chamber is broken away the foramen of the preceding chamber is seen as a simple rounded opening.

Dimensions of holotype: Greatest diameter 0.35 mm., thickness 0.20 mm.

Occurs frequently in the Omotumotu Beds; unknown elsewhere.

LAMARCKINA NOVOZEALANDICA
Dorreen, n. sp.
Plate 40, figure 1a–1d

Test planoconvex to biconvex, dorsal side flat in early portion, last chamber or two chambers convex, ventral side convex; about 1½ coils visible dorsally, seven to eight chambers in final coil; dorsal sutures distinct, limbate, periphery carinate, the raised carina fusing with the raised sutures; dorsal chambers between the sutures with prominent coarse granules, ventral side smooth and polished, umbilicate, the last-formed chamber with a convexly semicircular lip above the aperture.

Dimensions of holotype: Greatest diameter 0.50 mm., thickness 0.25 mm.

Holotype from Mahoenui Mudstone, above road tunnel, east entrance to Awakino Gorge, Taranaki.

This species resembles *L. ripleyensis* Cushman in many of its characteristics, but seems to be most closely related to the Australian *Lamarckina umbilicata* (Heron-Allen and Earland). *L. novozealandica* ranges at least into the Mahoenui Beds and probably higher.

Genus CERATOBULIMINA Toula, 1915
CERATOBULIMINA LORNENSIS Finlay
Plate 40, figure 2

Ceratobulimina lornensis FINLAY, 1939, Trans. Roy. Soc. New Zealand, vol. 69, pt. 1, p. 116, pl. 13, fig. 61.

Only one specimen was found of which the final chamber was broken away, revealing the foramen of the previous chamber. This foramen in no way resembles the aperture (Plummer, 1940) and the identification was made by comparison with a broken *C. lornensis* from the Kaiatan of Oamaru. It is an index species of the Kaiatan and Finlay (ibid.) notes its resemblance to *C. perplexa* Cushman and Harris and to *C. westraliensis* Parr.

Genus CEROBERTINA Finlay, 1939
CEROBERTINA KAKAHOICA Finlay
Plate 40, figures 3a, Cb

Cerobertina kakahoica FINLAY, 1939, Trans. Roy. Soc. New Zealand, vol. 69, pt. 1, p. 120, pl. 13, fig. 59.

This form occurs rarely in the Omotumotu beds. Finlay notes that it is always dextrally coiled and gives its range as Lower Bortonian-Whaingaroan.

Genus ROBERTINA d'Orbigny, 1846
ROBERTINA LORNENSIS Finlay
Plate 40, figures 4a, 4b

Robertina lornensis FINLAY, 1939, Trans. Roy. Soc. New Zealand, vol. 69, pt. 1, p. 114, pl. 12, figs. 27, 28.

Occurs rarely. Finlay notes its resemblance to *R. ovigera* (Terquem) and to *R. germanica* Cushman and Parker and states that it is an index species of the Kaiatan. However, I have one specimen from the Upper Bortonian of Hampden Beach which may be identical.

Family AMPHISTEGINIDAE
Genus ASTERIGERINA d'Orbigny, 1839
ASTERIGERINA CYCLOPS Dorreen, n. sp.
Plate 40, figures 5a–5c

Test dicoidal in axial section, low trochoid rounded spire, about 3½ whorls visible dorsally, 13 chambers to last whorl; periphery rounded without keel, dorsal sutures slightly curved, bent back to spiral suture at about 60°, dorsal surface of most of last whorl opaque, earlier whorls translucent

with indistinct sutures; proloculum appears like a small bubble imbedded in center of translucent area; ventral surface with mitre-shaped supplementary chambers between regular series, translucent shell material covers umbilical area; aperture a low interiomarginal slit; both terminal face and area of preceding whorl in front of aperture covered with granules as in *Amphistegina*.

Dimensions of holotype: Greatest diameter 0.60 mm., thickness 0.30 mm.

Occurs very commonly. Unknown elsewhere, probably a key species of the Kaiatan Resembles *Amphistegina floridana* Cushman and Ponton but possess more chambers.

Genus AMPHISTEGINA d'Orbigny, 1826
AMPHISTEGINA sp.
Plate 40, figure 6

Only one specimen found with aperture broken, so no description is attempted. In size it is larger than the average specimen of *Asterigerina cyclops* to which it bears a superficial resemblance. There are about 22 chambers to the adult whorl. Dorsal sutures are more strongly curved than those of *Asterigerina cyclops* and ventral sutures bifurcate between the umbilical clear shelly plug and the periphery.

Family CYMBALOPORIDAE
Genus HALKYARDIA Heron-Allen and Earland, 1919
HALKYARDIA BARTRUMI Parr
Plate 41, figures 1a, 1b

Halkyardia bartrumi PARR, W. J., 1934, Tertiary Foraminifera from Chalky Island, S. W. New Zealand, Trans. Roy. Soc. New Zealand, vol. 64, pt. 2, p. 144; pl. 20, figs. 3–6.

This species occurs abundantly in the Omotumotu fauna. It agrees exactly in size (1.15 mm.) with Parr's species from further south along the same coast. Finlay (1940, p. 111) regards the genus as being restricted to the Kaiatan stage.

Family CASSIDULINIDAE
Subfamily CASSIDULININAE
Genus CASSIDULINA d'Orbigny, 1826
CASSIDULINA cf. SUBGLOBOSA Brady

Cassidulina subglobosa BRADY, 1884, Rep. Challenger, vol. 9, p. 140, pl. 54, figs. 17 a–c.

This small *Cassidulina* is extremely like *C. subglobosa* in general appearance and possibly should be considered as belonging to that species. However, the figures in the Challenger Report show the oblique aperture in the terminal face commencing above the suture line between the two previous chambers, while the New Zealand specimens show the same type of aperture with the same degree of obliqueness, commencing from the suture dividing the two previous chambers. Neither are the sutures as depressed as those shown in Brady's figure. This species has been recorded as *C. calabra* Seguenza by Chapman (1926, p. 42, pl. 9, fig. 12.)

Family CHILOSTOMELLIDAE
Subfamily ALLOMORPHINELLINAE
Genus PULLENIA Parker and Jones, 1862
PULLENIA SPHAEROIDES (d'Orbigny)

Nonionina sphaeroides D'ORBIGNY, 1826, Ann. Sci. Nat., vol. 7, p. 293, no. 1; Modéle no. 43.
Pullenia sphaeroides (d'Orbigny) sp., BRADY, 1884, Rep. Challenger, vol. 9, p. 615, pl. 84, figs. 12, 13.

This widely distributed species is found in the entire New Zealand Tertiary. It occurs commonly in this fauna.

Subfamily SPHAEROIDININAE
Genus SPHAEROIDINA d'Orbigny, 1826
SPHAEROIDINA BULLOIDES d'Orbigny

Sphaeroidina bulloides D'ORBIGNY, 1826, Ann. Sci. Nat., vol. 7, p. 267, no. 1, Modéle no. 65.

This universal species is common in the Kaiatan fauna. It is distributed throughout the New Zealand Tertiary.

Family GLOBIGERINIDAE
Subfamily GLOBIGERININAE
Genus GLOBIGERINA d'Orbigny, 1826
GLOBIGERINA LINAPERTA Finlay

Globigerina linaperta FINLAY, 1939, Trans. Roy. Soc. New Zealand, vol, 69, pt. 1, p. 125, pl. 13, figs. 54–57.

This species, to which Finlay ascribes an Upper Cretaceous (Danian?) to Kaiatan range, occurs here rarely. The genus is poorly represented in this shallow water fauna.

Genus GLOBIGERINOIDES Cushman, 1927
GLOBIGERINOIDES INDEX Finlay
Plate 41, figure 2

Globigerinoides index FINLAY, 1939, Trans. Roy. Soc. New Zealand, vol. 69, pt. 1, p. 125, pl. 14, figs. 85–88.

This species occurs frequently in this fauna. Finlay gives its stratigraphic range as Bortonian to Kaiatan, i.e. Middle to Upper Eocene and compares it to *G. orbiformis* Cole from which it differs in possessing fewer chambers and being more loosely coiled.

Family ANOMALINIDAE
Subfamily CIBICIDINAE
Genus CIBICIDES Montfort, 1808
CIBICIDES PERFORATUS (Karrer)

Rotalia perforata KARRER, 1864, Novara Exped., Geol. Theil, vol. 1, p. 81, pl. 16, fig. 13.
Cibicides perforatus (Karrer) FINLAY, 1940, Trans. Roy. Soc. New Zealand, vol. 69, pt. 4, p. 461.

Occurs commonly. Species of this line have often been referred to *C. ungerianus* or to *C. pseudoungerianus.*

CIBICIDES PERFORATUS (Karrer)
var. NOTOCENICUS Dorreen, n. var.
Plate 41, figures 4a–4c

Test trochoid, dorsal surface flat or slightly raised, ventral surface strongly convex, bluntly conical; periphery with rounded keel; centre of dorsal surface occupied by roughly circular slightly raised shelly boss; eleven chambers in adult whorl, those of last formed whorl visible dorsally, all chambers except last three or four obscure ventrally, sutures curved, gently retroflexed, limbate; chambers with medium to coarse perforations dorsally; ventral surface smooth; interior-marginal aperture, with raised lip, extending over periphery and prolonged back dorsally for two chambers.

Dimensions of holotype: Greatest diameter 1.50 mm., thickness 0.25 mm.

Common.

This variety differs from *C. perforatus* in the possession of more prominent sutures and in being much more conical ventrally.

CIBICIDES VORTEX Dorreen, n. sp.
Plate 41, figures 5a–5c

Test trochoid, dorsal side flat, ventral convex, cone-shaped, usually with pseudoumbilical depression; periphery medium sharp with keel, nine to 10 chambers in adult whorl, all visible dorsally, about six of last whorl visible ventrally; dorsal sutures broad, but flush with surface, curved, gently retroflexed; those of the ventral surface depressed, retroflexed in a wide angled chevron pattern; wall thin, finely perforate; aperture situated between the terminal face and periphery of preceding whorl; when viewed from above, V-shaped, not extending backwards as far as penultimate suture.

Dimensions of holotype: Greatest diameter 1.50 mm., thickness 0.20 mm.

Common.

This species bears a strong resemblance to *C. refulgens* Montfort from which it differs in the possession of a pseudumbilicus and cone-shaped rather than rounded ventral surface.

CIBICIDES PSEUDOCONVEXUS Parr
Plate 41, figure 3

Cibicides pseudoconvexus PARR, W. J., 1938, Upper Eocene Foraminifera from Deep Borings in King's Park, Perth, Western Australia. Journ. Roy. Soc. West Australia, vol. 24, p. 86, pl. 3, figs. 5 a–c.

This peculiar species, described by Parr from the Western Austrialan Eocene, occurs commonly in this fauna. Its appearance suggests that it is an attached form.

Family PLANORBULINIDAE
Genus PLANORBULINA d'Orbigny, 1826
PLANORBULINA aff. MEDITERRANENSIS d'Orbigny

Planorbulina mediterranensis D'ORBIGNY, 1826, Ann. Sci. Nat., vol. 7, p. 280.

No complete specimens were found. However, this is a small flattish thin-walled *Planorbulina*, which shows affinities to *P. mediterranensis*. It occurs commonly.

Family RUPERTIIDAE
Genus CARPENTERIA Gray, 1858
CARPENTERIA aff. BULLOIDES Galloway and Heminway
Plate 41, figure 6

Carpenteria bulloides GALLOWAY and HEMINWAY, 1941, The Tertiary Foraminifera of Porto Rico, N. Y. Acad. Sci., Scientific Survey of Porto Rico and the Virgin Islands, vol. 3, pt. 4, p. 404, pl. 27, figs. 1–4.

A large *Carpenteria* of which no complete specimens were recovered occurs rarely. It agrees closely with *C. bulloides* described from the Lower Miocene Quebradillas formation of Porto Rico. The aperture is terminal and has a short neck. The surface is

ornamented with prominent pores and the point of attachment is small compared with *C. proteiformis*.

Galloway and Heminway suggest (ibid. p. 404) that the genus *Carpenteria* is in need of redefinition and also (p. 405) that the species of *Carpenteria* vary so widely that it is difficult to identify any of them.

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THREE NOTES ON ORDOVICIAN CYSTIDS

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ABSTRACT—(1) A new interpretation of the thecal plates of *Pleurocystites* is offered, with some notes on the morphology of the genus. (2) The four species (two new) of *Glyptocystites* are studied, and the deltoids, periproctals, hydropore, peristome and "radial depressions" described for the first time. (3) A specimen of *Amygdalocystites ? gorgo*, n. sp., shows the extent of some of the brachioles.

INTRODUCTION

THESE three short studies are unrelated, except that the second arose out of an attempt to settle problems raised by the first. They are part of a general review of the Trenton faunas of Ontario and Quebec. Three of the specimens studied were collected for the Geological Survey, Canada, and are in the Survey's collections. The other specimens are in the writer's collection, and a repository will be selected later.

The library of the New York State Museum has assisted greatly by the extended loan of literature. The Canadian Survey specimens were studied with the kind permission of Dr. W. A. Bell, Chief of the Palaeontological Division. Some of the text figures were made by Dr. G. G. Suffel, and the photographs by Mr. Charles Corke, of this University.

Regnèll has recently urged adoption of Jaekel's system of numbering the thecal plates in cystids, i.e., basals 1–4, infralaterals 1–5, laterals 1–5, etc. I agree that uniformity in this matter is very desirable, but Jaekel's scheme seems much more cumbersome than the equally familiar one used by Bather in which the plates are simply numbered from 1 to 24. If there is occasion, the basals, or any other circlet of plates, can be referred to as such. But the individual plates would have one number only. Thus there is only one plate 9, which would have to be referred to as IL 3 if Jaekel's system is followed, risking confusion with L 3 (plate 10). I prefer Jaekel's system of numbering the arms from I–V, instead of naming them.

References which are given in Bassler & Moodey (1943) are not repeated here.

I NOTES ON *PLEUROCYSTITES* BILLINGS

Relationship of the Deltoids and Radials.—The habit of *Pleurocystites* is so specialized that reconciliation of its structure with that of more typical, and presumably more primitive, cheirocrinids is difficult. The most recent work on the morphology of the genus is that of Bather (1913, pp. 450–494), whose conclusions have been generally copied. Bather's latest views are summarized in his text figure 62 of 1913 (our figure 2), which is his figure XXXIV, 3 of 1900 (our figure

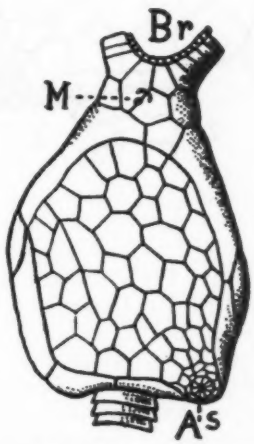

FIG. 1—Plates of anal side of *Pleurocystites*, after Bather 1900, fig. XXXIV, 3.

1) "with the necessary correction as regards plate 13, and with the numbering of the other plates as now adopted." However, it will be noted that there is also a significant change in the shape and relationships of

plate 17, with a corresponding loss of a plate from the anal side. These changes were not commented on in the text.

As it stands, Bather's interpretation seems reasonable, with the radial plates 17 and 19 folded to take part in both the anal (posterior) and the antanal (anterior) sides, and with the deltoid 20 similarly folded

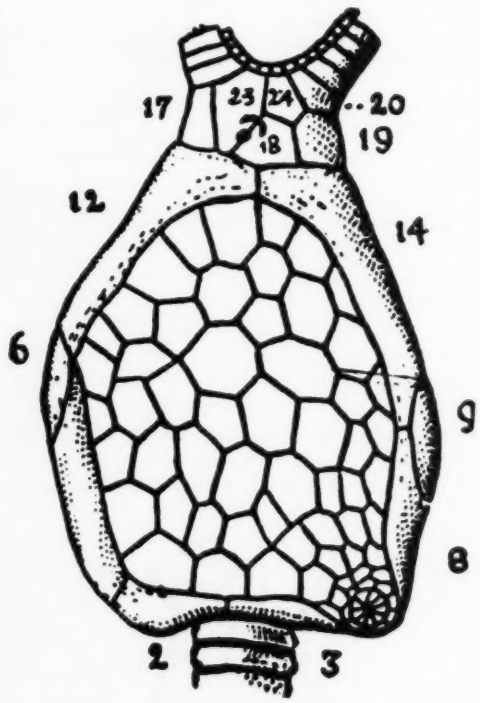

FIG. 2—Plates of anal side of *Pleurocystites*, after Bather 1913, fig. 62.

around the edge. The hydropore is shared by plates 23 and 18. The latter point is troublesome, although Bather apparently did not think it required special comment.

Study of an excellently preserved specimen has led me to question the accuracy of Bather's conclusions, and to offer an alternative explanation of the plate structure.

There is little room for disagreement concerning the plates from the stem to plate 16, but from here up interpretation is confused. I find that while plate 17 takes part in both faces, plate 19 does not, the two parts of Bather's 19 being separated by a clear suture. Bather's plate 20 is seen as confined to the anterior face. An attempt to reconcile these observations led to a new analysis of the upper part of the theca.

The plates on the anterior face have been less disturbed by the enlargement of the periproct than those of the posterior side, and a start must be made with them. The plate between 10/11 should be 16; the other radials showing on the anterior side, 15, 17 and 19. Plate 17 bends around to appear prominently on the posterior side, whereas 19 stops at the border of the theca and abuts against a posterior plate which should be 18 (plate 42, fig. 4). So much for the radials, at the moment.

Back on the anterior side; the three visible deltoids should be, as Bather labelled them, 20, 21 and 22. None of these continues onto the posterior side. This leaves us with three posterior plates lying between our plates 17 and 18. These I suggest are: 24 above and to the right, and to the left a bipartite plate 23 with the hydropore crossing the suture between the halves of the plate.

Objections to this interpretation are: (1) plate 19 is made to rest upon 14 alone, (2) plate 18 is removed from 12, which should normally support it, and (3) plate 24 rests upon the upper left shoulder of 18 rather than on the right between 18/19. Against these can be set the advantages that: (1) all the plates are accounted for, and (2) the hydropore is removed from the suture 23/18. The first point could be explained by supposition of a double plate 19, so that my interpretation rests mainly upon the position of the hydropore.

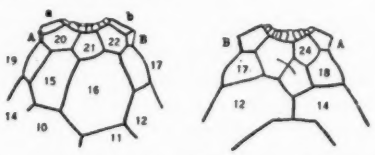

FIG. 3—Antanal and anal sides of *Pleurocystites*, based on the specimen figured on plate 42, figures 1–2. The antanal face has been viewed a little obliquely, so that plate A appears smaller than B. The plates joined by the pore are considered as parts of 23.

In no cystid known to me is the hydropore shared between plate 23 and a radial. In some cases (where 23 is missing) the pore may occur on a suture between two radials, but that is not a common occurrence. On

the other hand it is frequently found that plate 23 is split into more than one piece, with the pore crossing a suture within the plate. This is the case in *Schizocystis* (Bather 1900, fig. XXVII), *Callocystites* (Schuchert 1904, p. 242), *Hallicystis* (ibid., p. 216), *Coelocystis* (ibid., p. 247), *Lipsanocystis* (Ehlers & Leighly 1922, p. 156) and *Lovènicystis* (Regnèll 1945, p. 76). Bather also speaks of plate 23 of *Echinoencrinites* as "apparently bisected" (1900, p. 60).

In *Pleurocystites*' contemporaries, and presumed relatives, the same condition is found. A search was made for specimens of *Glyptocystites* and *Cheirocrinus* showing the posterior deltoid, and they are described below. Here it need only be mentioned that in these genera the hydropore is borne not only on two parts of plate 23, but that these parts lie one below the other, a condition very similar to that in *Pleurocystites*.

The objections listed above lead to a single conclusion: some of the radials and deltoids have been laterally displaced. Since considerable lateral displacement is accepted for the lower thecal plates, the additional shifting needed to bring the upper plates into the positions I have postulated is not disproportionate. It may be imagined that the conditions (active life?) which called for enlargement of the periproct also caused hypertrophy of the pore-bearing plate 23, with consequent lateral crowding of the adjoining plates.

Structure of the base of the brachioles.—On the posterior face the brachioles are seen to arise from a pair of widely pentagonal plates (figure 3, A and B), of which one (A) rests upon 24/18, the other (B) on 23/17. The former plate is that numbered 20 by Bather; the latter is omitted from his figure of 1913. These plates are similar in form, and each folds over the border of the theca to appear on the anterior face as a small quadratic piece outside the deltoids 20 and 22. Their symmetrical position suggests that they are part of the brachiolar sequence, and not thecal plates. In section each plate is J-shaped, with the long arm of the J on the posterior side, and the food groove running in the bend. The second arm of the J (on the anterior face) is completed by narrow bar-like plates (a and b) which rest entirely on plates 20 and 22. They are somewhat less than half the height of plates A and B, and are very much thinner. They seem entirely similar to the succeeding brachiolars, and are interpreted as the first plates of that series.

The covering plates of the food grooves, between the bases of the brachioles, are high flat pieces set in two rows. In the middle those on the posterior side are a little the longer, and lap over the anterior ones slightly. This relationship is seen to continue to brachiole Aa, but is reversed toward Bb.

With the new interpretation of the thecal elements the brachioles can be tentatively identified, assuming that *Pleurocystites* is descended from a cheirocrinid with five food grooves. One food groove (Aa) passes between plates 20/24, and therefore corresponds in position to plate 19; the other (Bb) passes between 22/23 and corresponds to plate 17. The brachioles should therefore be, respectively, I and IV. This interpretation is supported by the fact that plate 19, although it does not wholly support plate A, does lie under the part of it which bears the food groove.

Taxonomy.—The identification of the specimen on which these descriptions are based is a matter of some difficulty, due to confusion concerning the species *P. filitextus* Billings 1854 and *P. elegans* Billings 1857.

The latter was originally described (Billings, 1857, p. 287) as differing from *P. filitextus* in having shorter rhombs and a more strongly striated surface. In 1858 Billings (p. 51, pl. 2, 2a–d) expanded his description, and figured four specimens which differed among themselves in the apparent size and shape of the rhombs. All but figure 2c are said to be distorted. W. R. Billings (1881, p. 34) suggested that E. Billings' figure 2d was of *P. filitextus*, and that the two forms could be distinguished on the basis of the shape of the theca and the character of the upper rhombs. Jaekel (1899, p. 234) placed *P. elegans* in the synonymy of *P. filitextus*, without comment. Bather (1913, p. 466) considered them as two species, on the basis of W. R. Billings' remarks, with the only distinction the form of the rhombs and the stronger ornamentation of *P. elegans*. Bather at the same time named as holotype of this species "the specimen definitely mentioned

by E. Billings (1857) as in the Museum of the Geological Survey, Ottawa." I cannot find that Billings made such a statement, and Bather's citation must be considered a slip. Apart from this designation, no holotype has been selected for *P. elegans*.

Wilson has recently described and figured these species (1946, p. 13, pl. 3, 3–4). She states that *P. elegans* differs from other species in having "numerous, fine, radial striations" while *P. filitextus* has "roughened ornamentation." No distinction is noted in the rhombs, and her plesiotype of *P. elegans* seems to have rhombs quite as long as those of *P. filitextus* and the basal rhomb even appears to be larger than in that species. The periproctals in *P. elegans* are described as smaller than those of *P. filitextus*, but the difference is not given in detail. One periproctal in the specimen figured (the only one clearly seen) measures about 2.75 mm., while in *P. filitextus* these plates average 2.7 mm. according to Bather. *P. elegans* is described as having a wide posterior margin, but it is not clear how this compares with *P. filitextus*, which itself has a very wide margin. The condition of the rhombs, and the ornamentation, seem at odds with Billings' description, but Miss Wilson had access to the type material of both species and it can be assumed that her plesiotype of *P. elegans* agrees closely with the original specimens. If this is so, then the two species certainly seem to be the same, and Jaekel was correct in placing them both in *P. filitextus*.

The shape of the present specimen is close to that of *P. filitextus*, but the part above the shoulders of plates 12 and 14 is much shorter and therefore of quite different aspect (cf. plate 42, fig. 1 with Billings' (1858) pl. 2, fig. 1 b). The ornamentation does not agree very closely with either form, but it is a matter of individual variation in the genus, and cannot be relied upon for specific discrimination. The rhombs (especially the basal rhomb) are shorter than those of typical *P. filitextus*, but also shorter than those of *P. elegans* as given by Wilson. The periproct is much wider than in the type of *P. filitextus*, although the periproctals are of similar size. The species is left as *P.* cf. *filitextus* until more systematic work can be done on the genus as a whole.

The thecal plates are ornamented with a few strong ridges radiating from the umbones to the corners, and in some cases perpendicularly across the sutures. The rest of the surface is covered with nodes in rows at right angles to the sutures, and occasionally, near the umbones, by a few concentric ridges. On the posterior face the plates are smooth, or only irregularly granular.

Rhomb 10/14 is elongate, the half-rhomb on plate 14 the larger. The pore-area is narrowly lanceolate in outline and is surrounded by a rather wide border, which is wider on plate 14. There are about 33 slits, forming a level surface. The rhomb occupies almost the full width of the suture. (See plate 42, fig. 10. Since the upper rhombs stand at a high angle to the plane of the theca it is not possible to show their true outlines in a vertical photograph of the theca as a whole.)

Rhomb 11/12 (plate 42, fig. 3) occupies about three-fourths the width of the suture. It is kite-shaped, the half on plate 11 having a rather rounded outline and moderately wide border, that on plate 12 much the larger, with a rather sharply triangular outline and a border which in the middle is about half the width of the half-rhomb. The pore-area is lanceolate, almost equally distributed between the two plates, and has about 23 slits.

EXPLANATION OF PLATE 42

FIGS. *1–4, 10—Pleurocystites* cf. *filitextus* Billings. Cystid beds of Ottawa limestone, Hull, Quebec, *1, 2*, ×2. *3*, rhomb 11/12 ×3. *4*, the suture 18/19 ×3. *10*, rhomb 10/14 ×3. (p. 304)

5, 9—Glyptocystites multipora Billings. Cystid beds of Ottawa limestone, Hull, Quebec. *5*, plate 11, showing to the upper right the small rhomb on suture 12/17, ×3. *9*, portion of an an arm with the ambulacrals removed, showing the flat thecal plates ridges along the edges of the ambulacrals. Compare with plate 43, fig. 5. ×3. (p. 311)

6, 7—Pleurocystites cf. *filitextus* Billings. Sherman Fall formation, Peterborough, Ontario, ×1½ and ×3. (p. 304)

8—Amygdalocystites ? gorgo Sinclair, n. sp. Upper Trenton, Chateau Richer, Quebec. ×1. See text figure 6. (p. 313)

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Sinclair, Ordovician Cystids

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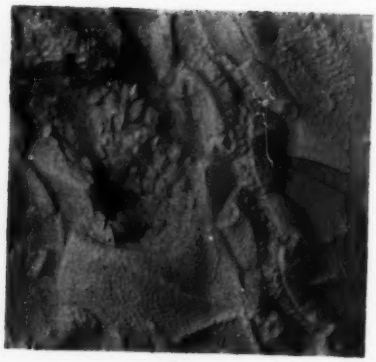

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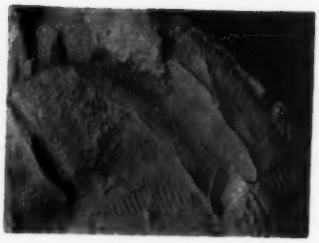

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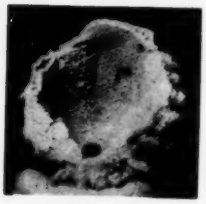

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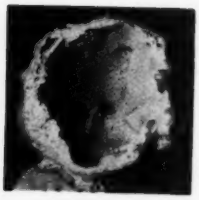

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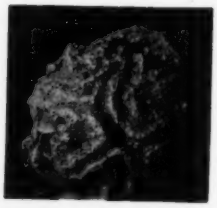

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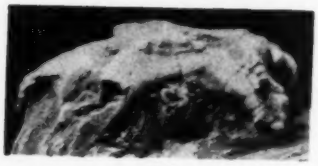

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Sinclair, Ordovician Cystids

Rhomb 1/5 is quadratic, occupying a little less than half the width of the suture. The edges are almost straight, and there is a wide border on each side. The portion on plate 1 is a little the larger. The pore-area is broadly elliptical, with about 14 slits.

The specimen is 34.5 mm. long, 25.5 mm. wide. Plate 5 measures 18.5 by 17 mm. Rhomb 10/14 is twice as long as wide. The ratio length ÷ width of periproct is 0.8. There are about 55 periproctals, counting the small plates near the vent.

The specimen was purchased from the estate of T. W. E. Sowter, of Aylmer, Quebec, and may have been collected by him or, more probably, by his collecting companion W. R. Billings. It certainly came from the cystid beds of the Ottawa limestone at Hull, Quebec.[1]

Distal structure of the brachioles.—Another specimen which must also remain nameless until the status of *P. elegans* is clarified is figured (plate 42, fig. 6–7) to show the structure of the brachiole. It differs from both *P. filitextus* and *P. elegans* in lacking the widened border on the rhombs. Rhomb 10/14 is wide, flat, with about two-thirds of the rhomb on plate 14, with about 25 slits occupying the whole surface. Rhomb 11/12 is small, with about 12 slits. Only the portion on plate 11 is seen, but that is shorter and more triangular than in either of the Ottawa forms. Rhomb 1/5 is small and short with about 11 slits. The shape of the theca (18 mm. long, 13 mm. wide) is rather like that of *P. filitextus*, but the rhombs are very different and plates 15 and 16 are much shorter.

The right brachiole seems to be essentially complete. It tapers very gradually for a length of 25 mm. (48 pairs of brachiolars) and then decreases abruptly in width, to taper again for a further length of 3 mm. (10 pairs of brachiolars). These distal brachiolars are quadrate rather than rectangular, i.e. the decrease in width is not accompanied by any corresponding decrease in the length of the individual plates.

The specimen is from the Middle Trenton Sherman Fall formation, from a small quarry 5 miles north of Peterborough, Ontario.

II Notes on *Glyptocystites* Billings

In some respects this genus has been well described, especially by Billings (1858, p. 53 ff.) and Jaekel (1899, p. 275 ff.), and attention will only be drawn here to new information, or that correcting previous errors. The descriptions are based on five species from the Trenton of Ontario and Quebec, which are described below. The four named species are the only ones known of the genus, with the exception of *G.? loeblichae* Bassler, which is discussed with them.

Pore rhombs.—The position and number of the rhombs is variable, but I have not

[1] A note may be in order concerning this horizon. Wilson (1946, p. 2) says "Subsequent work has shown that a greater variety of species is to be found near the top of the Cobourg beds [than in the Hull], most of them in the Cystid beds of Raymond." This I take to be a slip, since the cystid beds are not near the top of the Cobourg, but so close to the bottom that I have never felt sure whether they belonged there or in the underlying Sherman Fall. In consequence, when referring to them I have used the term "cystid beds," as implying no certain correlation. If the beds are to be correlated with the Cobourg, then they are at the very base of that formation.

Explanation of Plate 43

Figs. *1–5*—*Glyptocystites grandis* Sinclair. *1, 2*, posterior and anterior views of holotype, ×1. *4*, the suture 11/12 of the holotype, showing the two small rhombs, ×3. *3, 5*, details of another specimen, showing the periproct and the depressed thecal plates beneath the food groove, ×3. All from Kirkfield formation, Kirkfield, Ontario. (p. 311)

6—*Callocystites jewetti* Hall. Rochester shale, Lockport, New York. The rhomb 10/14, ×3. (p. 307)

7–13—*Glyptocystites* sp. Trenton group, Ontario, all ×1½. *7–9*, the interior of the upper part of the theca, showing the rhombs and radial depressions, and, in figure *8*, the depression of the hydropore. *10*, a latex mould of the same part of the theca. *11*, posterior side of the specimen, showing the periproct. *12*, anterior side. *13*, oral end, showing the large peristome, its outline obscured by the overhanging deltoids. (p. 312)

14—*Cheirocrinus* cf. *logani* (Billings). Rosemount member of Montreal formation, Montreal, Quebec. Posterior interradius with the pores crossing a suture in plate 23. ×3. (p. 312)

seen enough really good specimens to define the limits of variation. Some specimens seem to indicate that the course of the food grooves hindered or inhibited the development of the rhombs. It seems that the position of a rhomb was not fixed with reference to a particular suture, but only with reference to a given area of the theca. Thus in a specimen of *G. multipora* where the arm III almost covers the suture 11/12, a rhomb corresponding in size to that usually found there occurs on the adjacent suture 12/17. (plate 42, fig. 5). It is evident from the nature of the food grooves (solid exothecal plates with no connection with the interior of the theca) that from the early adult stages they occupied the thecal position which they hold later. As the theca increased in size, so they increased in length by the addition of stereom at the edges of the ambulacrals. The rhomb, on the other hand, started as a pore on a suture, more or less in the middle of its width. As the plates grew the original pore was removed more and more from the suture and became transformed into a long slit, while new pores were added laterally. Thus the development of the rhomb could be influenced by the position of the food groove, but not vice versa. Bather's suggestion that arm III is short because the rhomb 10/15 "acts as a bar," while possibly true phylogenetically, cannot be taken as a statement of the history of an individual, and should be re-examined.

The distribution of the rhombs in the specimens available to me is given in the following table, where + indicates the presence of a rhomb, − its absence, ± that the rhomb is present in some specimens but missing in others, and a blank that the suture is not seen clearly enough to be sure. The information on *G. loeblichae* is taken from Bassler's description, with the assumption that all the rhombs are mentioned, and that only where stated are the sutures obscured.

TABLE 1. DISTRIBUTION OF RHOMBS IN SPECIES OF GLYPTOCYSTITES

Rhomb	*multipora*	*grandis*	*batheri*	*regnèlli*	*loeblichae*
1/5	+	+	+	+	+
1/6	+	+	+	+	+
7/8	+	−	+		−
11/12	±	2	−	−	+
10/14	+	+	+	+	+
10/15	+	+	+	+	−
10/16	+	+	+	+	−
12/17	+	−		−	−
13/17	+	−		−	−
13/18	−	−	+	−	−
15/16	+	+	+	+	+
16/17	+	+	+	+	−
17/18	+	+	+	+	−
18/19	+	+	+	+	
19/15	+	+	+	−	−

Structure of the rhombs.—The rhombs of *Glyptocystites* are mostly widely disjunct, in a manner which I shall call "montidisjunct," but some of the smaller ones are conjunct, and in *G. regnèlli* most rhombs have a few conjunct slits at either end. Theoretically it may be imagined that each rhomb in its growth passed through a conjunct stage.

The rhombs of this genus are characterized by the elevation of one of the intrarhombic surfaces into a ridge, a condition which seems to be present in some other cystids as well (*Sphaerocystites*, Schuchert 1900, pl. 38; *Trimerocystis*, ibid., pl. 35, fig. 2–3; *Pseudocrinites*, ibid., pl. 35, fig. 10; *Tetracystis*, ibid., pl. 34, fig. 9–10; *Lepadocystis*, Foerste 1914, pl. 5, fig. 1; *Lovènicystis*, Regnèll 1945, pl. 3, fig. 10). This ridge lies just inside the inner edge of the slits on one side of the rhomb, and may be considerably raised (see plate 44, fig. 10). Such rhombs may be called montidisjunct. The position of the ridges in *Glyptocystites* is constant, and is shown in text figure 4. There it will be seen that there are ridges on plates 5, 6, 11, 13, 3 on 10, 2 on 16 (the two upper rhombs), 2 on 18, 1 on 19 (that of the rhomb 19/15). A rough pattern is apparent, with areas of the theca (plates 10, 18) faced

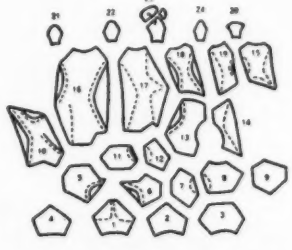

FIG. 4—Diagram of *Glyptocystites*, in part after Bather, but with the deltoids added. The dashed lines indicate the position of the pore-rhombs, the solid lines that of the intrarhombic ridges.

with ridged slits, and others (plates 17, 15) surrounded by unridged slits. It would seem that where possible a juxtaposition of ridged and unridged rhomb-halves is avoided.

Are these ridges purely adventitious, or had they a function? I suggest that they served to direct a stream of water emerging from the rhomb, and so preventing to some extent wasteful reuse.

If the rhombs were respiratory in function (a supposition which is discussed below) then water currents created by cilia must be imagined in the slits. A blind invagination, especially one with a restricted surface opening, is useless for respiration unless there is some mechanism for changing the water in contact with the respiratory surface. In most animals this is not a problem, since the respiratory sac is itself flexible, and water can be expelled by its contraction and readmitted by its relaxation. The calcitic walls of these rhombs, although thin, are rigid, and no such movement could have been possible. It is in keeping with echinoderm structure to postulate a ciliated ectodermal layer lining each of the slits, and creating water currents along it. A change from conjunct to disjunct types of rhomb would increase the efficiency of such a circulatory system by confining the current to an enclosed channel, open only at the inlet and outlet ends.

In such a system there would be an advantage in any device to prevent used water from returning to the intake end. I think we may regard the montidisjunct rhombs of *Glyptocystites* as such a primitive mechanism. The water entered at the unridged side, and left behind the ridge on the opposite side.

This interpretation is supported by the structure of the rhombs of some later cystids, e.g. *Callocystites jewetti* and *Jaekelocystis hartleyi*. In the former the rhombs are usually described as being "surrounded by a wall," but this is an over-simplification. The halves of the rhombs are widely separated, and one half is surrounded by a wall of spout-like proportions, the more prominent since the slits are depressed below the surface of the theca. But the other side is quite different. There the slits are almost level with the surface of the plate, which is flat to the common suture and to the sides. Only at the edge of the rhomb farthest from the suture is there a ridge (see plate 43, fig. 6). This arrangement seems very suggestive of an inlet and outlet system. In *Jaekelocystis hartleyi* (Schuchert 1900, p. 224, pl. 37, fig. 8) this is carried further with the constriction of the "outlet" into a small pore. Schuchert's figure was drawn looking down on this pore, so that its strong elevation (considering the size of the theca) is not seen. Schuchert says: "Dichopores on plates 1, 12 and 14 not shown at the surface, being deeply situated within small oval pits, each with a rim highly elevated above the surface of the plates." It is evident from specimens and from Schuchert's diagram that "plate 1" in this sentence is a misprint for plate 5. In both *Callocystites* and *Jaekelocystis* the outlet "spout" is on plates 5, 12 and 14. The upper thecal plates are too different in arrangement to allow correlation of the rhombs with those of *Glyptocystites*, but the supposed direction of flow through the basal rhombs is the same.

Function of the rhombs.—The question remains: Are the rhombs really respiratory in function? They are sometimes referred to as a part of the water-vascular system, but I know of no evidence to support such an interpretation. Recently Delpey (1946, p. 207 ff.) has suggested that they are sensory organs of equilibrium, specialized from epithecal nerves. I believe that the rhombs are respiratory and (a) that Delpey's conclusions can be shown to be improbable and (b) that the distribution of the rhombs can be explained in terms of a respiratory function.

I feel that Delpey has greatly weakened her thesis by an attempt to include the cheirocrinids in her scheme. The proprioceptor theory can be applied most plausibly to cystids with only three rhombs, in which the sensory function might be a secondary specialization of originally respiratory (or other) organs. The presumption of a sensory function rests mainly on the fact that in many genera the three rhombs stand roughly in three normally intersecting planes. The catch is in the word "roughly." If these are really organs of balance, then an exact relative position should be expected. I have not been able to satisfy myself that this is ever so. Even in *Pleurocystites*, which seems most

specialized for a vagrant life and therefore most in need of accurate knowledge of its position, there is no precise arrangement of the rhombs. Rather the upper rhombs follow in general the direction of the sides of the upper theca, and the angle between them changes with the "shoulder angle," so that it varies from 35° in *P. beckeri* to about 85° in *P. floriolus*. This is not a variation one would expect in an organ of balance.

Structurally there are difficulties in accepting Delpey's suggestion. It is essential for an organ of balance that the otoliths be shielded from any influence other than the movement of the animal. Usually the otocysts are either completely within the body or open to the exterior by a very small pore. In *Callocystites* we find the rhombs open for most of their length, and each rhomb surrounded by about 40 ciliated brachioles each creating a current in the water. The turbulence surrounding a *Callocystites* feeding at full speed would be most confusing to an otolith in one of the slits. I think the contrast between this structural arrangement and that necessary for a functioning proprioceptor is too great for reconciliation.

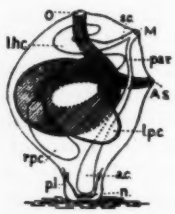

FIG. 5—Diagrammatic reconstruction of the imagined primitive pelmatozoic ancestor, after Bather 1900, fig. VII. O, mouth; As, anus; M, hydropore; par, parietal canal; ac, anterior coelom; sc, stone canal; lhc, left hydrocoel; lpc, left posterior coelom; rpc, right posterior coelom; pl, preoral lobe; n, nerves.

Why then do we find the rhombs where we do? I think the answer lies in an appreciation of what is being aërated. The gut is bathed in a constant stream of water; the hydrovascular system is in contact with the exterior through the hydropore. Neither of these systems requires a special respiratory mechanism. The coelom does. In echinoderms the coelom is extensive, and entirely cut off from the exterior. The varied respiratory mechanisms of modern members of the phylum are concerned with the oxygenation of the corpuscular coelomic fluid.

We cannot know directly where the coelomic cavities lay in a cystid, but I think that Bather's reasoning (1900, p. 9) is probably sound, and that his figure VII (our figure 5) can be used as an approximation of the possible arrangement. Referring to this figure, we find two coelomic pouches. One lies above the loop of the gut, roughly above or on the level of the anus, and against the anterior and lateral sides of the theca. The other lies below the gut, also in an anterior position. It will be immediately obvious that the position of the latter corresponds to that of the persistent basal rhombs in the cystids. The position of the upper cavity is less exact but agrees in a general way with the distribution of the upper rhombs. In three-rhombed cystids the two upper rhombs would lie one at either end of this coelomic cavity.

Bather's figure is, of course, hypothetical, but I think the agreement is suggestive. If it be accepted as causative, we might indeed plot the position of the coelom in other cystids by the distribution of the rhombs. Bather's reasoning in locating the gut still holds, but with a change in mechanism. There are no rhombs along its course, not because pressure inhibited them, but because the presence of the gut precluded that of the coelom, and the rhombs were functionally connected with the latter. The remarks above concerning the apparent inde-

EXPLANATION OF PLATE 44

FIGS. *1–9*—*Glyptocystites batheri* Sinclair, n. sp. Middle Trenton, Shipshaw river, Quebec. Holotype, Geological Survey Canada, 6295. *1*, anterior, *2*, posterior, *3*, anterior views, ×2. *4–9*, the deltoids ×3; *4*, plate 21, *5–6*, plate 23, *7*, plate 24, *8*, plate 22, *9*, plate 21. (p. 311)

10–14—*Glyptocystites regnélli* Sinclair, n. sp. Middle Trenton, Shipshaw river, Quebec. Holotype, GSC 6296. *10*, an oblique view showing the grooves on suture 19/15, and the height of the thecal and intrarhombic ridges, ×3. *11*, *12*, *14*, an oblique view of the posterior interradius and the anterior and left sides of the theca, ×2. *13*, the base, ×3. (p. 312)

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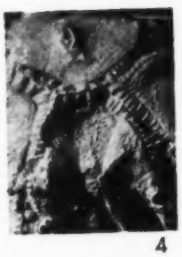

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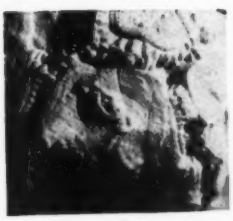

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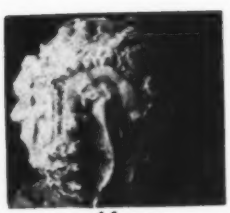

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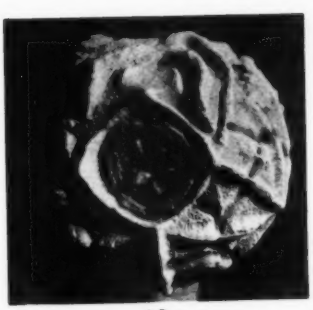

13

14

Sinclair, Ordovician Cystids

pendence of the rhombs and specific sutures have point here.[2]

Radial depressions.—I use this noncomittal term for structures of uncertain function which have been seen only in the silicified specimen of *Glyptocystites* sp. (plate 43, figures 7–10). The inner surface of each of the radials (15–19) bears a triangular depression which narrows and deepens aborally, and ends bluntly a little below the level of the top of the pore rhombs. The depressions become indistinct adorally, and except for those on plates 18 and 19 do not connect with anything else. The two mentioned are joined adorally by a groove which is continuous with the depression of the hydropore, and that on plate 18 is confluent with the right end of the hydropore. The depression on plate 17 has no such connection with the left end. The depressions vary somewhat in size, that on plate 15 being smaller than the rest.

Although the function of the depressions cannot be proven, some suggestions may be made. Sensory and motor nerves must have run along each food groove, and were probably accompanied by extensions of the coelom and hydrocoel, although the latter could be denied. These vessels all entered the theca by the peristome, there being no connection whatsoever through the thecal plates to the interior. The nerves united to form a circumoral ring, and the coelomic ducts joined the left posterior coelom. Presumably the extensions of the hydrovascular system connected with a ring canal, and through it with the hydropore. Analogy with other echinoderms suggests the presence of reservoirs somewhere between the ring canal and the hydrocoel extensions along the food grooves. It seems possible that each of the radial depressions housed part of one such reservoir, serving the food groove of that radius. There is no intrinsic reason why the depressions could not have been occupied by gonads, or caeca from the digestive tract, but I think the explanation given more probable.

Hydropore, gonopore.—The elongate, orad (if two are present) pore is referred to as the hydropore, the more compact pore farther from the mouth as the gonopore, in keeping with usual practice, without any real conviction of the implied homologies.

These pores are best seen in the holotype of *G. batheri*, but seem to be essentially similar in other species. On the surface there appears to be only one real pore, which lies on two parts of plate 23, across a suture. It is ovate, and situated on an elongate elevation. It seems to have been covered with small irregular plates. At either end of the elevation, beyond the region occupied by the pore, is a clear ovoid depression from which traces of linear depressions run inward, to the right of the gonopore. These two depressions, with their inward extensions, present the shape and position of a hydropore, but no penetration of the theca is evident. If there was a pore in the depressions it must have been minute, and is not now visible. The whole area is elongate in an almost vertical direction, running aboard a little to the right of the axis of the theca. From the lower end of the hydropore an obscure ridge runs down and to the left.

I have only one specimen (crushed) of *G. grandis* showing the posterior deltoid. There the pore is heart-shaped, and compared with *G. batheri* seems to comprise the gonopore with the two discrete depressions of the hydropore included on either side.

In *G. multipora* the pore-area is more elongate, less vertical, and the hydropore depressions are further removed from the gonopore. I have seen no specimens clear enough to permit detailed description.

In *G. regnèlli* the hydropore depressions are larger, and situated almost in line with the gonopore. A strong ridge runs down and to the left from the lower half of the hydropore.

Silicification in the specimen *Glyptocystites* sp. is too coarse to show more than the fact that internally there is a transverse depression corresponding in position to the

[2] Bather's idealized figure of a glyptocystid, showing the distribution of the rhombs and the inferred course of the gut, has been so widely quoted that it may be well to point out an error which has never been corrected. This figure (1913, p. 439, fig. 45) shows "The actual distribution of all the pore-rhombs known with certainty in the Glyptocystidae," but actually omits the rhomb 7/8 which is present in Bather's figure 38 of *Glyptocystites multipora*. The fact that this rhomb lies athwart the gut of figure 45 is not as serious as it seems, as in *Glyptocystites* the periproct does not reach plate 7, and therefore the gut does not have to cross the suture 7/8.

pore-area, and separated from the margin of the peristome by a pronounced ridge.

Peristome.—The peristome, as seen in *Glyptocystites* sp., (plate 43, figures 8, 13) is a rather large ovate aperture with its long axis perpendicular to arm III. The outline is even, with no perceptible notching for passage of the food grooves. Although the sutures cannot be seen, there is nothing to suggest that the margins are not formed by the deltoids, the orad edges of which overhang the opening itself. Internally the edge is not elevated, except at the posterior side.

Parietal septum.—In any specimen of *Glyptocystites* a striking difference is seen between the attitude of the rhomb 17/18 and the rest of the upper rhombs. In general the latter are vertical with reference to the axis of the theca, and midway between the two bordering food grooves. Rhomb 17/18, on the contrary, is oblique and displaced to the right. This leaves a smooth tract running down plate 17, below the hydropore. The probability that this smooth space marks the path of the parietal septum or canal need not be laboured. The subsequent course of the parietal structures is not clear, but in *G. regnèlli* a ridge runs from the lower end of the hydropore across plates 23, 17 and 12, ending at the median umbone of the latter. Jaekel (p. 126) shows the parietal septum in *Echinoencrinites* as running through plates 12–6–2, a course which is quite possible here, but not provable. No parietal structures are seen on the interior of the theca.

Food grooves.—The ambulacrals are very simple pentagonal plates alternately arranged. Jaekel's figure (pl. 15, fig. 4a) showing accessory plates is not in agreement with my specimens, and I suspect that the drawing was influenced by the condition in the Callocystidae. The plates are much longer than wide, with a sinuous distal outline. They meet in the middle along a zigzag median suture. The brachiole facets are rather small and situated about halfway along the ambulacral, frequently so far out that the arm as a whole has a beaded appearance. A shallow groove runs obliquely orad from the facet to the main food groove. The latter lies entirely on the depressed inner portions of the ambulacrals. The thecal plates may be depressed below the food grooves (plate 43, fig. 5), but frequently are not (plate 42, fig. 9).

The brachioles are long and slender, and present no novelties of construction. The number per arm is the same in one individual (except for arm III), but it is not known to what extent the number might vary within a species.

Extension of four of the arms to the basal plates has been considered a generic character, but in *G. regnèlli* arm IV is much shorter than usual. The special case of *G. ? loeblichae* is discussed below.

Periproctals.—These plates still cannot be described completely. They are small, irregular in shape, and have granular surfaces. They are smaller and cuneiform peripherally, larger and more quadrate in the middle. The position of the anus is not known. The holotype of *G. batheri* shows elongate periproctals arranged more or less radially above a point on the lower margin of the periproct at plate 8, but no actual vent is seen. Specimens of *G. grandis* suggest that the vent was not at the lower margin, but give no definite evidence of its location. Bather thought it might be in the upper right portion of the periproct, a possibility which my specimens do not deny. (In Bather's diagrams the anal pyramid shown is to be taken as a conventional sign, and not an indication of the structure of the periproct.)

Thecal plates.—I have nothing to add here, except to confirm Jaekel's observation that plates 5 and 6 do not meet, being separated by the upward extension of plate 1, which always touches plate 11 along a narrow suture.

The deltoids have never been described for the genus, and indeed some recent diagnoses have ignored them completely. Bather did not show them in his diagrams, as he did not know their outlines. Jaekel showed them in some figures, but not in others, but he stated that they are covered by the arms and cannot be seen, so that his representation of them in the diagrams must be taken as conjectural. Actually, the deltoids are clearly visible in most well-preserved specimens. The food grooves do not cover them, but run between them. The structure is the same throughout the genus, but the plates will be described from *G. batheri*, in which they are best seen.

Plates 20 and 21 are broadly club-shaped,

with the oral edges broadly rounded; 22 is more elongate, with a sharply rounded oral edge; 24 is smaller, pentagonal, with a sharp angle above. Plate 23 is tripartite, consisting of two subquadrate plates bordering the food grooves, the left of which is much larger than the right, and an aboral, elongate, irregularly pentagonal plate with irregularly curved sides. The pores are shared by this lower plate and the larger of the two upper ones. The deltoids lie at a rather high angle to the sides of the theca, so that the top of the theca is sharply truncated (plate 44, fig. 1).

The deltoids of *G. multipora* and *G. grandis* are similar, but have a median longitudinal ridge running orad from the upper angle of the rhomb on the subjacent suture. Those of *G. regnèlli* are similar, but proportionately smaller.

Species of *Glyptocystites*

Glyptocystites multipora Billings 1854

Plate 42, figures 5, 9

Glyptocystites multiporus Wilson 1946, p. 15.

The specimen which I have for study is not too well preserved, but a few notes can be based on it. The rhomb 11/12 described by Billings is missing, but there is in its place a small rhomb 12/17, with seven conjunct slits. Rhomb 7/8 is not complete, showing only a little more than the upper half, with about 11 disjunct slits. Rhomb 18/19 is more lanceolate than rhombic. Plates 13 and 14 have short transverse ridges just above the periproct. The latter is more elongate below than in Billings' figures, but this may be due to distortion. The deltoids are poorly defined, but are generally similar to those described above in *G. batheri*, except that 24, 21 and 22 have a longitudinal median ridge more or less continuing the point of the underlying rhombs.

As Billings noted, the ambulacrals are very loosely attached to the theca, and flake off readily. The thecal plates are not depressed beneath them, but are flat, or even a little elevated, and are slightly ridged along the sutures.

The specimen is 23 mm. high, 14.5 by 12 mm. wide.

From the middle Trenton cystid beds of the Ottawa limestone, at Hull, Quebec.

Glyptocystites grandis Sinclair 1945

Plate 43, figures 1–5

Sinclair 1945, p. 73, pl. 2, figs. 4–5.

This species was described briefly in 1945 in order that the name could be used in a faunal list. At that time I overlooked the use of this specific name in a list by Winchell and Ulrich (1897, p. cxxiii). Ulrich's manuscript name does not seem to have been used elsewhere. Compared with *G. multipora* it is consistently larger, the food grooves are definitely depressed, the periproct is elongate rather than transverse, rhomb 13/17 is missing, there is a small secondary rhomb on 11/12, plate 24 is shorter, and the rhomb 18/19 extends much further orad.

All my specimens are more or less flattened, so that the true shape of the theca cannot be seen. The excellent preservation of the brachioles unfortunately obscures the sutures and rhombs in many places, so that the species cannot be described in full detail. Rhomb 19/15 is small, with only 17 slits, but is very definite, contrasting with the genotype, in which the rhomb is so indistinct that according to Billings it is "only seen in perfect specimens." The upper and lower halves of rhomb 16/17 do not meet, as the lower part is much narrower than the upper, as well as being a good deal shorter. The brachiole facets project less laterally than in *G. multipora*, so that the arm has a less beaded appearance. Each arm has about 18–20 brachioles, except III, which is not well seen on any of the specimens. The periproctals are small, but seem to be larger than those of *G. batheri*.

The species is common in the lower Trenton Kirkfield formation in central Ontario, especially in the vicinity of Kirkfield (from which the type and the figured specimens came), and I have recognized it from possibly equivalent beds in Quebec.

Glyptocystites batheri Sinclair, n. sp.

Plate 44, figures 1–9

A large robust species, similar in aspect to *G. grandis*. Compared with that species, plate 11 is large and simply ridged, without rhombs. The parts of rhomb 16/17 meet. Rhombs 15/16 and 19/15 are both large, the latter with about 50 slits, the former with about 25 slits in the upper half. The intrarhombic ridges are lower and more rounded,

and the ornamentation of the theca as a whole is simpler.

The deltoids are almost horizontal above, giving the theca a truncated appearance which contrasts with the more conical *G. multipora*. The arms have 15 facets each, except III, which has seven. Arm V does not pass on plates 8 or 9. (In *G. multipora*, and apparently also in *G. grandis*, this arm passes over plate 8 to plate 3.)

The holotype, Geological Survey, Canada, Collections 6295, is 34 mm. high, 22 by 19 mm. wide.

It, and a paratype GSC 6295a, were found in a shaly limestone of Middle Trenton age on the Shipshaw river, below Chute aux Galets, Co. Chicoutimi, Quebec.

The specific name is for the late Dr. F. A. Bather.

GLYPTOCYSTITES REGNÈLLI Sinclair, n. sp.
Plate 44, figures 10–14

A moderate sized species, the plates with granular surfaces and very strong ridges, the intrarhombic ridges very prominent. Arm IV is short, reaching to plate 14. Rhomb 19/15 is missing.

The surface ridges are very striking. They cross the sutures, but narrow sharply in doing so. The arm IV seems to run into a ridge on plate 14, and is about two-thirds the length of I, II and V. III has the normal short form of the genus, with about six brachioles. The long arms have 13. The suture 19/15 has no rhomb, but is crossed by three broad shallow grooves which occupy most of the triangular space between arms III and IV. These grooves widen and deepen at the suture, but no pore is visible. The arms and brachioles are not unusual. The periproct is not seen.

The matrix of the only specimen has partially recrystallized, making further preparation hazardous.

Holotype, GSC 6296, is 19 mm. high, 16 mm. wide.

From a shaly limestone of Middle Trenton age, at Chute aux Galets on the Shipshaw river, Co. Chicoutimi, Quebec. The horizon is a few feet above that of *G. batheri*, but they are part of the same fauna.

The specific name is for Dr. Gerhard Regnèll of Stockholm.

GLYPTOCYSTITES sp. ind.
Plate 43, figures 7–13

This specimen, from which many structural notes were taken, was found in an old collection with an entirely useless label. It is quite certain that it came from the Trenton of central Ontario. It is rather coarsely silicified, and has been freed of matrix and broken to show the interior. The cover plates of the food grooves are missing, and the detailed course of the arms themselves, the surface structure of the rhombs, and the sutures cannot be distinguished. A fissure filled with silica crosses the periproct, and the periproctals are missing.

The inner surface of the thecal plates is smooth, and unaffected by the ridging of the exterior. There is no trace on the inner surface of excavation for the gut, nor any structure corresponding to parietal organs. The rhombs, peristome and radial depressions have been described above.

The specimen agrees well in shape and in the development of the intrarhombic ridges with *G. regnèlli*, but there are five radial rhombs. It approximates *G. multipora* in size about 26 mm. high, 18 mm. wide). Specific identification is not warranted.

GLYPTOCYSTITES ? LOEBLICHAE Bassler
Bassler 1943, p. 702, pl. 1, figs. 8–9.

This species, with its five arms so short that they only indent the upper edges of the radials, cannot be placed in *Glyptocystites* without extending the genus beyond useful limits. I do not feel prepared to suggest another genus for it on the basis of Bassler's description, but its position should be reexamined. On the face of it, it is not clear why it could not be a *Cheirocrinus*.

The species was described from the lower part of the Simpson group of Oklahoma.

THE HYDROPORE OF *CHEIROCRINUS*

Several hundred specimens of *Cheirocrinus* from Montreal were examined in an attempt to clarify the structure of the posterior deltoids, but only one gave any definite information (plate 43, fig. 14). The oral edge of plate 23 is bisected by a suture which divides a small quadratic plate on the right from a larger one on the left. Below and between these plates is a larger one, the

aboral outline of which is not clearly seen. The upper plates are bent down sharply along a definite line, and the orad portions stand higher than the rest. The line bends on the right plate, so that a triangular depression is formed, occupying about one-sixth the area of the plate. On the left plate a low border is formed, running along the aboral edge of the plate, and taking up one-fifth its width.

The pores lie on this low edge of the upper left plate, and cross the suture onto the lower plate. They consist of (1) a linear slit with raised edges, perpendicular to the suture, the hydropore, and (2) immediately aborad of this a pair of semielliptical depressions surrounded by a strong raised border, the gonopore. The whole has the appearance of a broadly heart-shaped locket suspended from a bar.

Most of the theca is buried in matrix, and the species cannot be identified with certainty at present. It will be considered later in more detail in connection with a larger work on the genus.

The specimen is from the Rosemount member of the Montreal formation (Clark 1945, p. 29) at the Botanical Gardens quarry, Montreal. It was collected by an anonymous Boy Scout and given to me by Mr. E. R. Patterson of Montreal. The horizon is distinctly lower than the beds in which *Cheirocrinus logani* is common, but the specimen is not dissimilar in aspect, and may be referred to as *C.* cf. *logani.*

III A Brachioliferous Amygdalocystitid
Amygdalocystites ? gorgo
Sinclair, n. sp.
Plate 42, figure 8, text figure 6

The specimen is preserved as a glauconitic film[3] in such a way that the outline is clear, but no relief is seen, nor can any details of structure be determined. The theca is ovate, with the oral end the larger. The lower end is broadly rounded. There is no suggestion that this represents the original outline—indeed the attitude of some of the brachioles strongly suggests that the theca was not lying on its side when compressed. The theca is 41 mm. long, 29.5 mm. in maximum width. The stem, 2 mm. wide, is preserved for about 17 mm., and does not taper appreciably in that length. The thecal plates are not well seen, but in the lower left quadrant they appear to be small and irregularly hexagonal, ranging in width from 1.5 to 2.0 mm.

Fig. 6—Outline of *Amydalocystites ? gorgo.* Traced from the photograph on plate 42, figure 8. The indentation at the right is due to deficient preservation; the outline was presumably even.

The striking feature of the specimen is that some of the brachioles are preserved, and show an entirely unsuspected length. The longest measures 43 mm.—longer than the theca itself. Since the brachioles show no tapering, there is nothing to indicate how nearly complete this length might be. Seven definite (and two more possible) brachioles arise from the upper right margin, which presumably coincides fairly well with the position of an arm. On the left side, however, four brachioles (three of which are about 40 mm. long) appear to originate at a point well within the thecal outline. This suggests that a food groove, now indistinguishable, passes across the theca roughly in the direction taken by the brachioles.

[3] Identification by Professor G. H. Reavely.

Nothing can be seen of the structure of the brachioles, but the free curves in some of them indicate that they were very flexible.

The specimen is from the Upper Trenton, in M. Gravel's quarry, Chateau Richer, Co. Montmorenci, Quebec.

The genus is, of course, indeterminate. It might be *Amygdalocystites* or *Platycystites*, genera of very similar aspect which differ importantly in the position of the anus, or, more accurately, in the identity of the remaining two arms. *Ottawacystites* (Wilson 1946, p. 14) might be considered, but it is not clear how that genus differs from *Amygdalocystites*. The "free arms" seem from the description and figures rather to be stout brachioles, and indeed it is difficult to imagine the organization of a cystid with true arms in such a position. The present specimen has been referred to *Amygdalocystites* solely because that genus is known to occur in the Trenton of this area.

The propriety of giving the specimen a specific name is more debatable. It seems clear from its size and general shape that it does not belong to a described species, but it is very doubtful if another, normally preserved, specimen could be identified with it. On the other hand, unless another such freak turns up, our knowledge that the group possessed such brachioles will rest on this specimen, and it seems wise to name it so that reference can be made to it.

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MIDDLE CAMBRIAN TRILOBITES FROM THE CONGLOMERATES OF QUEBEC (EXCLUSIVE OF THE PTYCHOPARIIDEA)

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ABSTRACT—This paper contains the description of the Middle Cambrian Agnostida, Eodiscida and Bathyuriscidea from the conglomerate boulders of the lower St. Lawrence valley. Forty species are discussed, 31 of which are new. Three new genera, *Bathyuriscidella*, *Orriella* and *Corynexochides*, are established. Most of the species are represented by excellently preserved material.

The fossils indicate the presence of Middle Cambrian boulders of different ages, ranging from early to late Middle Cambrian. The faunas are closely related to those of the Cordilleran province; only certain Agnostids show affinities with species from the Atlantic province.

INTRODUCTION

IN A recent paper (Rasetti, 1948) the writer described the Lower Cambrian trilobites of the conglomerates outcropping in the lower St. Lawrence valley. The present paper includes the description of the Middle Cambrian forms from the same conglomerates.

In this as in the preceding paper, the ptychoparids are left out of consideration. The Lower and Middle Cambrian ptychoparids from the conglomerates of Quebec, which include several scores of species, have been studied and the species separated. However, when trying to assign them to genera, the writer found the taxonomy so confusing that he prefers to postpone this task to a time when it will be possible to study most of the Lower and Middle Cambrian ptychoparids of North America and revise their classification.

For this reason, the ptychoparid trilobite genera as now used have generally a poor value as index fossils, and in the writer's opinion the use of these genera for designating zones in the Lower and Middle Cambrian should as far as possible be avoided.

The writer is indebted to Dr. G. Arthur Cooper for permission to study and photograph type specimens in the collections of the U. S. National Museum. The field expenses in 1945 were defrayed by a project grant from the Penrose Bequest of The Geological Society of America.

OCCURRENCE OF THE FOSSILS

All the fossils discussed herein, excepting one species described by Walcott, were collected by the writer from the conglomerates outcropping on the south shore of the St. Lawrence from Lévis to Grosses Roches. The conglomerate outcrops, probably all of Canadian age, have been discussed in several publications (Rasetti, 1945a, 1945b, 1946a); hence only a short summary of the localities for Middle Cambrian fossils is given, beginning with Lévis and proceeding toward the northeast.

Lévis.—The occurrence of boulders with Middle Cambrian fossils in certain bands of conglomerate at Lévis was recently reported (Rasetti, 1948). The collections, however, did not yield any species that are not better represented elsewhere.

Island of Orléans and Ville Guay.—The conglomerate bed designated (Rasetti, 1946a) as the Ville Guay conglomerate outcrops at Ville Guay, 4½ miles east of Lévis, and on the opposite shore of the Island of Orléans. At both places it contains numerous fossiliferous boulders. It was first believed (Rasetti, 1945b) that all these boulders were Lower Cambrian, but further study (Rasetti, 1948) showed that there is a Middle Cambrian as well as a Lower Cambrian assemblage.

Boulders from Ville Guay are designated by the letter L, boulders from the Island of Orléans by the letter O.

St. Simon.—One species described by Walcott (1890) from the conglomerate outcrop at St. Simon, *Agraulos redpathi*, and believed by him and by Resser to be of Lower Cambrian age, is probably Middle Cambrian. The same species is common at other localities. It is not discussed here, being a ptychoparid.

Bic.—Most of the fossiliferous boulders from Bic yield Lower Cambrian fossils, but one boulder, collected by the writer, contained species of Middle Cambrian age. Boulders from Bic are designated by the letter B.

Métis.—The conglomerates of the Métis area (Rasetti, 1945a) contain fossiliferous boulders of Lower, Middle and Upper Cambrian age. The Lower and Upper Cambrian trilobites were already described. Walcott (1890) described a ptychoparid, *Ptychoparia mêtisensis*, assigning it to the Lower Cambrian. Resser made it the genotype of the genus *Métisia*. The associations of this species prove that its age is late Middle Cambrian. Boulders from Métis are designated by the letter M.

Grosses Roches.—The conglomerates of the Grosses Roches area are identical with those at Métis, yielding the same fossil assemblages (Rasetti, 1945a). Boulders from Grosses Roches are designated by the letter G.

The Middle Cambrian fossils from the limestone boulders at all the localities mentioned are characterized by their excellent state of preservation. The test is almost invariably preserved and the ornamentation of the upper surface can be observed. In a few cases almost complete shields have been recovered. A very unusual occurrence was an assemblage of a large number of complete, enrolled specimens of *Hypagnostus mêtisensis* in a small portion of boulder M-19. All the specimens were crowded in a dark concretion, about one-half inch in thickness and a few square inches in area. This piece of rock looked like an oolite made of enrolled agnostid shields.

Another unusual occurrence is the exceptional abundance of shields of various species of *Bathyuriscidella* in certain boulders. For example, in boulder M-6 an appreciable fraction of the rock was made of the fragments of one species, *Bathyuriscidella socialis*. There must have been fragments representing thousands of individuals within a few pounds of rock. Several almost complete shields of this species were recovered.

AGE OF THE FAUNAS

The difficulty of assigning a more precise stratigraphic position to several Middle Cambrian assemblages recovered from these conglomerates emphasizes the lack of well-established faunal zones for the Middle Cambrian of the Appalachian and Cordilleran provinces. Most of the genera from the conglomerates of Quebec are identical with or closely related to the genera from the Cordilleran province, where the standard Middle Cambrian sections are located. Nevertheless it is difficult to determine the stratigraphic position of the Quebec species with any accuracy. This is due to the char-

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EXPLANATION OF PLATE 45

The test is preserved in all the figured specimens unless otherwise indicated.

FIGS. *1–3*—*Peronopsis gaspensis* Rasetti, n. sp., ×5. *2*, Pygidium; Laval U. 450 a, holotype. *1*, Cephalon. *3*, Pygidium; Laval U. 450b–c, paratypes. (p. 319)

4, 5—*Peronopsis* cf. *P. gaspensis* Rasetti, ×5. *4*, Cephalon. *5*, Pygidium. Laval U. 451a–b. (p. 319)

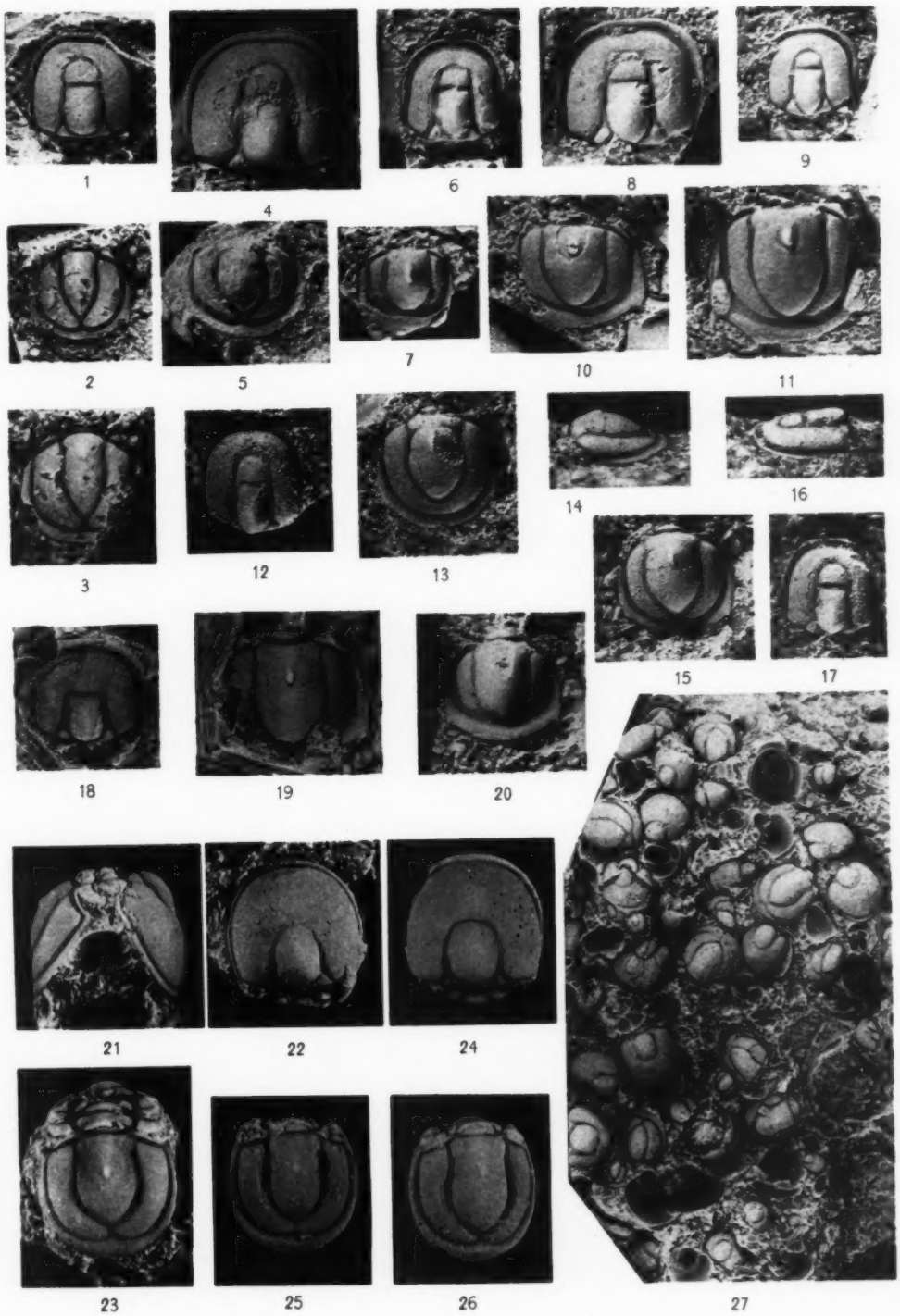
6, 7—*Peronopsis marginalis* Rasetti, n. sp., ×5. *6*, Cephalon; Laval U. 452b, paratype. *7*, Pygidium; Laval U. 452a, holotype. (p. 319)

8–11—*Peronopsis* sp. undet. no. 1, ×5. *8, 9*, Cephala. *10, 11*, Pygidia; Laval U. 453a–d. (p. 320)

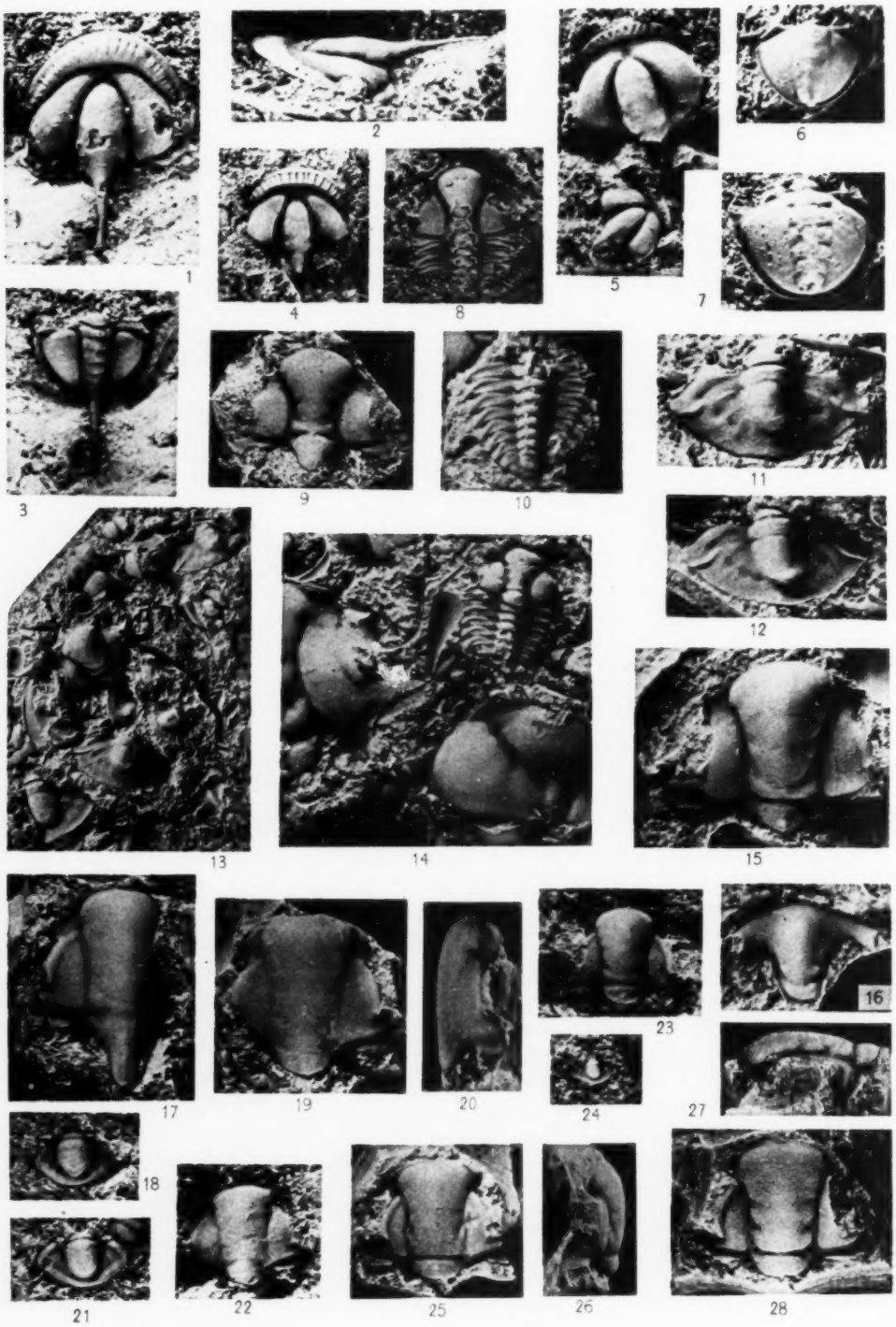
12–17—*Peronopsis* sp. undet. no. 2, ×5. *12*, Cephalon. *13*, Pygidium, *14, 15*, Side and top views of another pygidium. *16, 17*, Side and top views of another cephalon; Laval U. 454a–d. (p. 320)

18–20—*Kormagnostus antiquus* Rasetti, n. sp. *18*, Cephalon, ×5; Laval U. 456a, holotype. *19*, Pygidium, ×5. *20*, Smaller pygidium, ×8; Laval U. 456b–c, paratypes. (p. 321)

21–27—*Hypagnostus mêtisensis* Rasetti, n. sp. *21–23*, Lateral, cephalic and pygidial views of partially enrolled specimen, ×6; Laval U. 455a, holotype. *24–25*, Three exfoliated, enrolled specimens, ×6. *27*, Piece of limestone covered with the shields of this species, ×2.5; Laval U. 455b–e, paratypes. (p. 320)



Rasetti, Quebec Middle Cambrian Trilobites



Rasetti, Quebec Middle Cambrian Trilobites

acter of the western Middle Cambrian faunas. Ptychoparid genera are so similar and poorly defined as to be seldom of much value for correlation. Other trilobites, such as those of the bathyuriscid type, are more distinctive, but most of the common genera have a long range. Little stratigraphic value can be assigned to faunal zones designated after such genera as *Kootenia*, *Olenoides*, *Zacanthoides* or *Bathyuriscus*, which are known to range through large portions of the Middle Cambrian.

It is clear that the boulders from the St. Lawrence valley belong to several distinct horizons, but it is at present impossible to state how many. Broadly speaking, there is an assemblage (the only Middle Cambrian assemblage present in the Ville Guay conglomerate) which is of early Middle Cambrian age. The most common and typical genera are *Kootenia* (represented by many species), *Zacanthoides*, *Pagetia*, the new genus *Corynexochides*, and many characteristic ptychoparids not discussed in this paper. A very late Middle Cambrian assemblage, represented only at Grosses Roches and Métis, includes *Hemirhodon*, the new genera *Bathyuriscidella* and *Orriella*, the ptychoparid *Métisia*, and many other forms. There are also certain boulders that cannot be definitely considered either early or late Middle Cambrian and which probably occupy an intermediate stratigraphic position. For example, boulder M-24 from Métis yielded a species of *Kootenia*, similar to or identical with a form contained in some of the boulders of the Ville Guay conglomerate, and a species of *Zacanthoides*. These fossils would suggest an early Middle Cambrian age. However, other species collected from the same boulder, such as *Bathyuriscidella expansa*, are more indicative of the late Middle Cambrian. A similar case is that of boulder M-19, yielding *Olenoides mětisensis*, *Hypagnostus mětisensis*, etc. These boulders may, at least tentatively, be considered representative of the middle portion of the Middle Cambrian.

Tables 1 and 2 give a list of the faunal associations of all the species discussed in this paper. The numerous ptychoparids are not included in this list, as they are mostly undescribed.

SYSTEMATIC DESCRIPTIONS

The classification adopted has been discussed in the preceding paper (Rasetti, 1948). The terminology employed is that proposed by Howell, Frederickson, Lochman, Raasch and Rasetti (1947).

EXPLANATION OF PLATE 46

The test is preserved in all the figured specimens unless otherwise indicated.

FIGS. *1–4—Pagetia ellsi* Rasetti. *1*, Cranidium, ×8. *2*, Side view of another cranidium, ×8. *3*, Perfect pygidium preserving the axial spine, ×8; Laval U. 457a–c, plesiotypes. *4*, Cranidium, ×6; Laval U. 305a, holotype. (p. 321)

5–7—Pagetia billingsi Rasetti, ×8. *5*, Two cranidia, the larger one being the holotype; Laval U. 306a. *6*, *7*, Pygidia with the axial spines broken off; Laval U. 306b–c, paratypes. (p. 322)

8, *9—Corynexochides latifrons* Rasetti, n. sp., ×5. *8*, Cranidium and three thoracic segments; Laval U. 470b, paratype. *9*, Cranidium; Laval U. 470a, holotype. (p. 329)

10–16—Corynexochides gregarius Rasetti, n. gen., n. sp. *15*, Cranidium, ×6; Laval U. 465a, holotype. *10*, Seven thoracic segments and pygidium, ×6. *11*, *12*, Pygidia, ×6. *13*, Piece of limestone with many fragments, ×3. *14*, Cranidium with six thoracic segments and portions of two larger cranidia, ×6. *16*, Hypostoma, ×6. Laval U. 465b–g, paratypes. (p. 327)

17, *18—Corynexochides longicollis* Rasetti, n. sp. *17*, Cranidium, ×4; Laval U. 469a, holotype. *18*, Pygidium, ×5; Laval U. 469b, paratype. (p. 328)

19–22—Corynexochides laevigatus Rasetti, n. sp., ×5. *19*, *20*, Top and side views of cranidium; Laval U. 468a, holotype. *21*, Pygidium. *22*, Cranidium; Laval U. 468b–c, paratypes. (p. 328)

23, *24—Corynexochides bicensis* Rasetti, n. sp., ×5. *23*, Cranidium; Laval U. 466a, holotype. *24*, Pygidium; Laval U. 466b, paratype. (p. 328)

25, *26—Corynexochides sublaevis* Rasetti, n. sp., ×5. Top and side views of cranidium; Laval U. 467a, holotype. (p. 328)

27, *28—Corynexochides constrictus* Rasetti, n. sp., ×5. Side and top views of cranidium; Laval U. 471a, holotype. (p. 329)

TABLE 1. FAUNAL ASSOCIATIONS IN THE EARLY MIDDLE CAMBRIAN BOULDERS

Boulder	L-3	L-4	L-5	L-7	L-8	L-9	L-12	L-13	L-16	O-27	O-33	O-34	O-36	M-3	M-23	M-25	G-37	G-46	B-13
Albertella sp. undet.					×														
Corynexochides bicensis Rasetti, n. sp.																			×
Corynexochides constrictus Rasetti, n. sp.						×		×											
Corynexochides gregarius Rasetti, n. sp.															×				
Corynexochides laevigatus Rasetti, n. sp.			×									×							
Corynexochides latifrons Rasetti, n. sp.														×					
Corynexochides longicollis Rasetti, n. sp.																		×	
Corynexochides sublaevis Rasetti, n. sp.		×	×																
Kootenia billingsi Rasetti, n. sp.				×					×										
Kootenia ellsi (Walcott)										×	×								
Kootenia elongata Rasetti, n. sp.		×																	
Kootenia gaspensis Rasetti, n. sp.														×					
Kootenia parallela Rasetti, n. sp.	×												××						
Kootenia quebecensis Rasetti, n. sp.																×			
Kootenia rotundata Rasetti, n. sp.													××						
Kootenia sp. undet.	×				×		×								×				
Olenoides brevistylus Rasetti, n. sp.																×			
Olenoides foveolatus Rasetti, n. sp.								×											
Olenoides granulatus Rasetti, n. sp.																			×
Olenoides cf. *O. serratus* (Rominger)						××													
Pagetia billingsi Rasetti						×													
Pagetia ellsi Rasetti		×			×					×		××					×		
Peronopsis sp. undet. no. 2	×						×					×							

The width of the fixed cheeks given as a fraction of the glabellar width includes the palpebral lobes.

All descriptions refer to the upper surface of the test unless otherwise indicated.

ORDER AGNOSTIDA

The recent, splendid monograph of the Middle Cambrian agnostids from Sweden, published by Westergård (1946), gives for the first time a clear idea of many genera

TABLE 2. FAUNAL ASSOCIATIONS IN THE LATE MIDDLE CAMBRIAN BOULDERS

A few of the boulders in this list may be somewhat older than the majority, particularly boulders M-19 and M-24

Boulder	M-6	M-8	M-12	M-19	M-24	G-5	G-6	G-12	G-31	G-32	G-34	G-36	G-43
Bathyuriscidella amplicauda Rasetti, n. sp.		×											
Bathyuriscidella expansa Rasetti, n. sp.					×						×	×	
Bathyuriscidella longicauda Rasetti, n. sp.						×							
Bathyuriscidella obliqua Rasetti, n. sp.			×										
Bathyuriscidella socialis Rasetti, n. sp.	×								×				
Bathyuriscidella spinulosa Rasetti, n. sp.										×			
Bathyuriscus sp. undet.								×					
Hemirhodon convexifrons Rasetti, n. sp.			×			×							
Hypagnostus mélisensis Rasetti, n. sp.				×									
Kootenia sp. undet.					×								
Kormagnostus antiquus Rasetti, n. sp.	×												
Olenoides convexus Rasetti, n. sp.							×					×	
Olenoides mélisensis Rasetti, n. sp.				×									
Peronopsis gaspensis Rasetti, n. sp.													×
Peronopsis cf. *P. gaspensis* Rasetti								×					
Peronopsis marginalis Rasetti, n. sp.				×								×	
Peronopsis sp. undet. no. 1					×								
Zacanthoides sp. undet.					×								

based on Scandinavian genotypes, and permits a close comparison with the American forms.

It is interesting to note among the species from the conglomerates of Quebec several agnostids having close relatives in the Atlantic province, a relationship which is almost never observed among the other trilobites. This cosmopolitan character of agnostid genera has been commented upon by several writers. Certain authors have been reluctant to place forms from the Atlantic and the Cordilleran provinces in the same genus. However, when as it happens in the case of several agnostids, no significant morphologic differences exist in any part of the shield, separation on the mere suspicion of parallel development in distantly related stocks appears unjustified. Apparently such genera as *Agnostus* (*s.s.*), *Glyptagnostus*, *Homagnostus*, *Peronopsis*, *Pseudagnostus*, etc. must be allowed a wide geographic distribution.

The agnostid genera here discussed will be classified according to Westergård.

Family AGNOSTIDAE McCoy
Subfamily PERONOPSINAE Westergård
Genus PERONOPSIS Corda, 1847

PERONOPSIS GASPENSIS Rasetti, n. sp.
Plate 45, figures 1–3

Known from several associated cephala and pygidia.

Cephalon subquadrate, anterior angles well rounded. Glabella parallel-sided. Posterior lobe twice as long as the anterior lobe, somewhat more elevated posteriorly. Transverse furrow straight. Anterior lobe well defined by a shallow dorsal furrow. No tubercles on the glabella. Occipital ring very narrow, continuous with the small, triangular basal lobes. Cheeks convex; marginal furrow narrow but rather deep. Border narrow, convex, of even width throughout.

Pygidium with an elongated rhachis occupying more than two-thirds of the length. Rhachis rather suddenly narrowed immediately behind the anterior end, then widened slightly and finally tapered rapidly to a rather pointed end. There is a low elongated tubercle less than one-third of the way from the anterior end. There are no furrows across the rhachis. Pleural lobes moderately convex, separated mesially by a short longitudinal postaxial furrow that joins the dorsal and marginal furrows. Marginal furrow well impressed. Border moderately convex, wider than on the cephalon. Pygidial spines small and short.

Length of cranidium 3.0 mm., of pygidium 3.0 mm. Surface smooth.

This species is extremely similar to *P. scutalis* (Hicks) as figured by Westergård, the chief difference being that the latter lacks pygidial spines. It is also very similar to *P. acadica* (Hartt), from which it can be separated by the same character. *P. gaspensis* belongs to the group characterized by a median postaxial furrow on the pygidium, for which Kobayashi erected the genus *Acadagnostus*. Following Westergård these forms are placed in *Peronopsis*.

Boulder G-43, Grosses Roches.

Holotype and paratypes.—Laval University nos. 450a–d.

PERONOPSIS cf. P. GASPENSIS Rasetti
Plate 45, figures 4, 5

Known from a few cephala and associated pygidia.

This form differs from the typical *P. gaspensis* in the proportionately wider and shorter shields, faint lateral furrows on the rhachis, and lesser distance between the end of the rhachis and the marginal furrow. The number of specimens is too small to decide whether these small differences are to be considered of specific rank.

Boulder G-12, Grosses Roches.

Figured specimens.—Laval University nos. 451a–b.

PERONOPSIS MARGINALIS Rasetti, n. sp.
Plate 45, figures 6, 7

Known from several cephala and associated pygidia, besides an enrolled shield.

Cephalon typical of *Peronopsis*. Glabella parallel-sided; posterior lobe about twice as long as the anterior lobe and more elevated. A faint elongated tubercle on the posterior lobe. Occipital ring very narrow mesially, continuous with the basal lobes, which are triangular and of average size. Cheeks of average convexity, marginal furrow broad and shallow, border narrow.

Pygidial rhachis rather wide for the genus. There is a faint indication of two short furrows at the sides. The rhachis is narrowest

between the two pairs of furrows, slightly widening behind the posterior pair of furrows, and is well rounded posteriorly. An elongated tubercle just in front of the middle. Marginal furrow shallow. Border of the usual type anteriorly and laterally, expanded mesially so as to come within a very short distance of the rhachis.

Surface smooth. Length of largest cephalon 3 mm., of pygidium 2.5 mm.

This species hardly differs from several described ones as far as the cephalon is concerned, but the pygidium is distinctive because of the peculiar border and the plumper axis than in most species of the genus.

Boulders G-36, Grosses Roches, and M-19, Métis (holotype from the former). In boulder M-19, this species was associated with large numbers of enrolled individuals of *Hypagnostus métisensis*.

Holotype and paratypes.—Laval University nos. 452a-h.

PERONOPSIS sp. undet. no. 1
Plate 45, figures 8–11

Known from several cephala and associated pygidia.

Glabella of the type usual in the genus. Anterior lobe semicircular, occupying one-fourth of the length. Transverse furrow straight. Posterior lobe parallel-sided, simple, without tubercles. Occipital lobes rather large, triangular. Cheeks convex, without median furrow. Marginal furrow moderately deep and wide; border narrow, convex.

Pygidium with a rhachis that almost reaches the marginal furrow, although this furrow does not merge with the dorsal furrow. Rhachis very slightly constricted just behind the anterior margin, the constriction being marked by a pair of exceedingly short and shallow axial furrows; then widened very slightly, and finally tapered to a somewhat pointed end. There is a rather strong tubercle at one-third the distance from the anterior margin. Marginal furrow rather wide and shallow. Border wide, of almost uniform width except near the anterior angles where it is narrower. Marginal spines short but fairly wide. In one of the specimens there is a pair of tubercles on the border at the base of the spines. Surface smooth.

Length of largest cephalon 3.8 mm., of pygidium 4.0 mm.

This form is so similar to *P. fallax* (Linnarsson) or some of its described Swedish varieties that it should possibly be identified with it. In Sweden, *P. fallax* and its varieties range through a considerable thickness of the Middle Cambrian, hence the identification would be of little value for correlation.

Boulder M-24, Métis.

Figured specimens.—Laval University nos. 453a–d.

PERONOPSIS sp. undet. no. 2
Plate 45, figures 12–17

Known from several cranidia and associated pygidia.

This form is similar to the preceding and also typical of *Peronopsis*. The anterior glabellar lobe appears to be longer than in *P. fallax* and its varieties. The pygidium has a rhachis with two distinct pairs of short furrows at the sides, and is more definitely constricted at the level of the anterior furrows. The rhachis in certain specimens reaches the marginal furrow, whereas in others it does not. There may be two species, but the material is too scanty to decide this point. Westergård observed a great deal of variability in this character among Swedish agnostids.

Boulders L-3 and L-12, Ville Guay. This form seems to be early Middle Cambrian since only fossils of that age have been identified from the Ville Guay conglomerate.

Figured specimens.—Laval University nos. 454a–d.

Genus HYPAGNOSTUS Jaekel, 1909
HYPAGNOSTUS MÉTISENSIS
Rasetti, n. sp.
Plate 45, figures 21–27

Known from numerous complete, mostly enrolled specimens.

Cephalon of equal length and width, well rounded anteriorly. Glabella limited to a posterior lobe, occupying less than half the cephalic length, with the maximum width in the middle, rounded in front. Dorsal furrow rather deep posteriorly, shallow in front of the glabella but still distinct. Some specimens show an extremely faint tubercle in the middle of the glabella. Occipital ring limited to triangular side lobes. Cheeks rather strongly convex. Marginal furrow narrow but clearly distinct. Border extremely narrow.

Thoracic axial segments with a pair of shallow oblique furrows at the sides defining anterolateral lobes. Pleura with a narrow furrow parallel and very near to the anterior margin.

Pygidium of the same form as the cephalon. Rhachis occupying more than two-thirds of the length, slightly constricted by a pair of faint indentations at one-fifth of the distance from the anterior margin, then slightly widened, finally tapering to a rather sharp point. Some specimens show a trace of two instead of one pair of faint furrows at the sides. There is an elongated tubercle just in advance of the midpoint. Dorsal furrow joining the marginal furrow through a short longitudinal depression. Pleural lobes narrower than the axis. Marginal furrow narrow but well impressed, curving forward mesially. Border convex, much wider than the cephalic border, widest mesially. Surface smooth.

Length of largest complete specimen 8.0 mm., of cephalon 3.3 mm., of pygidium 3.3 mm.

This species is quite typical of the genus, so far known chiefly from the Atlantic province. It is extremely close to the genotype, *H. parvifrons* (Linnarsson) from Sweden, from which it differs chiefly in the narrower cephalic border. Another very similar species is *H. clypeus* Whitehouse from northeastern Australia.

Boulder M-19, Métis.

Holotype and paratypes.—Laval University nos. 455a–z.

Subfamily AGNOSTINAE Jaekel, 1909
Genus KORMAGNOSTUS Resser, 1938
KORMAGNOSTUS ANTIQUUS
Rasetti, n. sp.
Plate 45, figures 18–20

Known from a few cephala and associated pygidia.

Cephalon somewhat wider than long. Glabella limited to a posterior lobe, parallel-sided, sharply truncated in front by a straight furrow. A faint tubercle somewhat in advance of the midpoint of the posterior lobe. Occipital ring extremely narrow mesially, laterally confluent with triangular basal lobes of average size. Cheeks of average convexity. Marginal furrow of moderate depth and width, separating a narrow, convex border.

Pygidial rhachis rather prominent, occupying one-half of the pygidial width and five-sixth of the pygidial length. Rhachis very slightly wider posteriorly, well rounded at the end. Traces of two pairs of axial furrows are visible at the sides on some of the specimens. There is a small but rather elevated tubercle at the level of the anterior third of the rhachis. Pleural lobes rather narrow at the sides; marginal furrow wide and shallow, border considerably wider than the cephalic border. The rhachis reaches the marginal furrow. Marginal spines small.

Length of largest cephalon 3.5 mm., of largest pygidium 4.6 mm. Surface apparently smooth.

This species differs from the genotype, *K. simplex* Resser of early Upper Cambrian (Dresbach) age, in the proportionately shorter shields and parallel-sided glabella. The writer (Rasetti, 1946b) also collected *K. simplex* from the Upper Cambrian boulders at Métis and Grosses Roches. In the present case, however, the late Middle Cambrian age of the fossil cannot be doubted, in view of the association with *Bathyuriscidella socialis* and other typically Middle Cambrian forms.

Boulder M-6, Métis.

Holotype and paratypes.—Laval University nos. 456a–e.

ORDER EODISCIDA
Family PAGETIIDAE Kobayashi
Genus PAGETIA Walcott, 1916
PAGETIA ELLSI Rasetti
Plate 46, figures 1–4

Pagetia ellsi RASETTI, 1945, Am. Jour. Sci., vol. 243, p. 315, pl. 2, figs. 13–18.

This species was described as Lower Cambrian, but later the writer (Rasetti, 1948), after more complete study of the faunas from the Ville Guay conglomerate, concluded that this trilobite belongs to an early Middle Cambrian fauna.

Besides the holotype, new specimens from Grosses Roches are figured, since they show certain features better than the types.

Holotype and paratypes.—From boulder O-34, Island of Orléans: Laval University nos. 305a–m. Plesiotypes (from boulder G-37, Grosses Roches): Laval University nos. 457a–f.

PAGETIA BILLINGSI Rasetti
Plate 46, figures 5–7

Pagetia billingsi RASETTI, 1945, Am. Jour. Sci., vol. 243, p. 316, pl. 2, figs. 9–12.

The types are refigured.

Boulder L-9, Ville Guay.

Holotype and paratypes.—Laval University nos. 306a–c.

ORDER OPISTHOPARIA
Superfamily BATHYURISCIDEA Richter
Family BATHYURISCIDAE Richter
Genus BATHYURISCUS Meek, 1873
BATHYURISCUS sp. undet.
Plate 48, figure 24

This species is represented only by the pygidium, hence specific identification is not attempted.

Pygidium typical of the non-spined group of *Bathyuriscus*. Axis occupying about three-fourths of the length, with four segments, a terminal unsegmented section, and a post-axial ridge. Pleural lobes with five pairs of furrows and interpleural grooves of the shape typical of the genus. Border narrow, poorly defined.

This pygidium is almost identical with that of *B. rotundatus* (Rominger) from the *Ogygopsis* shale of British Columbia.

Boulder G-12, Grosses Roches.

Figured specimen.—Laval University no. 458a.

Genus BATHYURISCIDELLA Rasetti, n. gen.

Entire shield rather flat, tapering from a large cephalon to a small pygidium.

Glabella narrow and long, expanding forward, reaching the anterior margin. Posterior glabellar furrows oblique, well impressed; one to three other pairs short, usually shallow. Occipital ring wide, without spine. Brim developed only at the sides; border upturned. Palpebral lobes of medium length, narrow; ocular ridges present. Anterior branch of facial suture parallel to the dorsal furrow, straight to the margin. Posterior branch defining long, narrowly triangular or parallel-sided posterior limbs. Free cheeks wide, with an upturned border; genal spines of moderate length. Hypostoma with long, stout anterior wings which have a semicircular cross section and are sharply truncated. Anterior and posterior lobes separated by a furrow. Maculae distinct. Border with angular outline, forming a pair of short spines.

Thorax of nine segments in genotype. Axis narrow, convex. Pleura flat, furrowed, straight almost to the end, terminated in sharp spines.

Pygidium much smaller than the cephalon, approximately semicircular. Axis strongly prominent, with few segments and a postaxial ridge. Pleural lobes flat, with shallow furrows and grooves. Border poorly defined, sometimes with marginal spines.

Genotype: *Bathyuriscidella socialis* Rasetti, n. sp.

Stratigraphic range: late Middle Cambrian.

Remarks.—This genus has many characters in common with *Bathyuriscus*, *Poliella*, *Athabaskia* and *Clavaspidella*, and is undoubtedly closely related to all of them. However, the species assigned to *Bathyuriscidella* have a set of common characters of their own which induced the writer to establish a new genus.

Bathyuriscidella differs from *Bathyuriscus* chiefly in the characters of the pygidium, which is smaller and composed of a lesser number of segments. *Poliella* has longer palpebral lobes and the thoracic pleura do not end in spines. *Athabaskia* (which, in the writer's opinion, Resser incorrectly united with *Clavaspidella*) has longer palpebral lobes, and a proportionately larger pygidium with greater number of segments. *Clavaspidella* has the eyes more distant from the glabella and a different pygidium. *Bathyuriscidella* has on the average a higher stratigraphic position than all the above-mentioned genera.

One described species may be assigned to *Bathyuriscidella*. This is *Bathyuriscus* (*Poliella*) *probus* Walcott from the Marjum formation of Utah, later doubtfully assigned by Resser to *Clavaspidella*.

Several species from the conglomerates are described. Each boulder never yielded more than one species, usually represented by great numbers of fragments sometimes constituting a considerable fraction of the rock.

BATHYURISCIDELLA SOCIALIS
Rasetti, n. sp.
Plate 47, figures 1–12

Known from several nearly entire shields

and many hundreds of fragments recovered from a single boulder.

Glabella reaching the anterior margin of the head, moderately expanding forward in the anterior half, with the minimum width near the middle. Posterior glabellar furrows strong, oblique, almost meeting mesially. Another pair short and shallow, two others indistinct. Occipital furrow straight, shallow mesially. Occipital ring wide, rounded, with a small node. Anterior outline of cranidium straight. Border developed only at the sides, flat, differentiated from the brim by its upturned position. Anterior pits well developed. Ocular ridges moderately oblique, narrow; palpebral lobes about one-fifth the length of the glabella, wider than the ocular ridges, moderately curved, set off by a distinct palpebral furrow. Distance between the posterior end of the palpebral lobe and the dorsal furrow almost half of the glabellar width. Posterior limbs with a wide furrow. Anterior branch of the facial suture parallel to the dorsal furrow and distant from it one-fourth the glabellar width. Posterior branch directed first outward and then curving backward, defining long, moderately wide posterior limbs.

Free cheek wide, flat; marginal furrow well impressed anteriorly but gradually becoming obsolete toward the genal angle. Genal spine rather strong, cylindrical.

Hypostoma as described in the generic diagnosis. Transverse furrow very close to the posterior margin. Short marginal spines at the level of the maculae. The hypostomas of trilobites of this type are fused with the rostrum, represented by the strong, long anterior wings. The wings are truncated by the sutures separating the rostrum from the free cheeks; while the anterior margin of the hypostoma is directly connected to the cranidium (hence in this species to the glabella, as there is no anterior border) by the facial suture (the hypostomal suture being fused). Hypostomas of this type occur in many or perhaps all of the bathyuriscid genera, and this character of the sutures seems to constitute one of their important diagnostic features. For some reason the ventral cephalic sutures of Cambrian trilobites have seldom been discussed since Barrande published his classic work.

Thorax of nine segments, with axis occupying about one-fifth of the width. Axial segments without spines or nodes. Pleura with a moderately deep, wide furrow starting from the anterolateral angle and distally occupying the middle of each pleuron. Ends of pleura forming slender spines, directed slightly downward. The spines of the fifth and eighth segments are much longer than the others and directed slightly upward.

Pygidium almost twice wider than long. Axis strongly prominent, most elevated posteriorly so that its longitudinal profile is slightly concave. Axis occupying two-thirds of the length, followed by a postaxial ridge. Two axial furrows impressed at the sides besides the articulating furrow. Pleural lobes depressed; two pairs of pleural furrows and interpleural grooves, shallower in larger pygidia, sometimes rather indistinct. Border narrow, slightly convex, poorly defined by the marginal furrow. Most of the pygidia present a pair of very short spines a little behind the anterior angles.

Length of largest cranidium observed 10 mm. Surface smooth.

Boulder M-6, Métis.

Holotype and paratypes.—Laval University nos. 459a–z.

Bathyuriscidella spinulosa Rasetti, n. sp.
Plate 47, figures 13–16

Known from a large number of cranidia and associated pygidia.

This species is so similar to the preceding that it is sufficient to point out the differences instead of repeating a complete description.

Cranidium practically indistinguishable from that of *B. socialis*. Thorax represented by isolated segments similar to those of *B. socialis*.

Pygidium of the same general shape as in *B. socialis*, but with three pairs of small, backward-directed marginal spines. A feature that can be noted on this pygidium and to a lesser extent in *B. socialis*, is the distinctness of the first interpleural groove. Hence the first segment of the pygidium preserves to a great extent the characters of a thoracic segment. A similar state of affairs obtains in species of *Corynexochides* to be described in this paper, and appears more markedly in other trilobites, e.g. in *Housia*.

Length of largest cranidium 8 mm. Surface smooth.

Boulder G-32, Grosses Roches.
Holotype and paratypes.—Laval University nos. 460a–u.

BATHYURISCIDELLA EXPANSA
Rasetti, n sp.
Plate 48, figures 10–16

Known from numerous cranidia and associated pygidia.

Cranidium similar to that of *B. socialis*, from which it can be distinguished by the following characters. Anterior outline less straight; glabella more markedly expanded forward in the anterior third; four pairs of glabellar furrows always distinct; ocular ridges more oblique, corresponding to the more posterior position of the palpebral lobes; posterior limbs narrower, almost parallel-sided, with a small intergenal spine.

Pygidium oval rather than semicircular, with a much less straight anterior margin than in *B. socialis*. Axis occupying two-thirds of the length, strongly prominent, followed by a postaxial ridge. Two axial furrows distinct, of almost uniform depth. Pleural platforms slightly convex; border wide, concave, poorly defined, with a slight median posterior notch. Pleural furrows and grooves rather indistinct. Most pygidia show a pair of very small, blunt marginal spines at the posterolateral angles.

Length of largest cranidium 12 mm. Surface smooth.

The individuals assigned to this species show some variation in the shape of the glabella, distinctness of the glabellar furrows, and shape of the pygidium. Since these differences are small and there are transitional forms, it does not seem proper to make more than one species.

Boulders G-34 and G-36, Grosses Roches and M-24, Métis (holotype from the first). *Holotype and paratypes.*—Laval University nos. 461a–t.

BATHYURISCIDELLA AMPLICAUDA
Rasetti, n. sp.
Plate 48, figures 4–9

Known from numerous cranidia and associated free cheeks, hypostomas and pygidia.

This species closely resembles *B. socialis* and is described by indicating the differences.

Cranidium much like in *B. socialis*, but with the glabella more rapidly expanding forward in the anterior third. Border at the sides of the glabella wider, more strongly upturned. Palpebral lobes more posteriorly situated, more curved, longer and wider. Posterior limbs very narrow, parallel-sided.

Hypostoma tapering backward more strongly than in *B. socialis*, with wider anterior wings.

Thoracic segments apparently similar to those of *B. socialis;* it is not known whether the fifth and eighth have special features.

Pygidium probably larger in proportion to the cephalon than in *B. socialis*. Axis occupying only half of the length, strongly elevated posteriorly, extended into a strong postaxial ridge. Two pairs of axial furrows strongly impressed as pits at the sides but almost obsolete mesially. Pleural lobes wider

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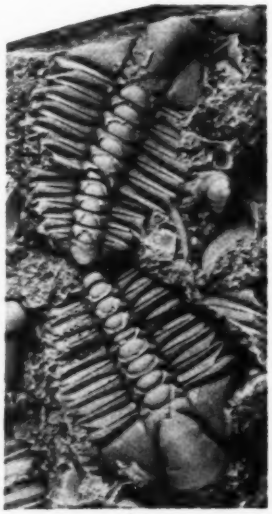
EXPLANATION OF PLATE 47

The test is preserved in all the figured specimens unless otherwise indicated.

FIGS. *1–12—Bathyuriscidella socialis* Rasetti, n. gen., n. sp. *9, 10,* Top and side views of cranidium, ×3; Laval U. 459a, holotype. *1,* Two small, almost complete shields, ×6. *2,* Cranidium with three attached thoracic segments and pygidium, ×4. *3,* Hypostoma, ×4. *4,* Seven articulated thoracic segments, showing long pleural spines of fifth and eighth segments, ×6. *5, 6,* Side and top views of pygidium, ×3. *7,* Free cheek, ×3. *8,* Pygidium, ×3. *11,* Cranidium, ×3. *12,* Unusual pygidium with almost obsolete furrows and lacking the small marginal spines, ×3. Laval U. 459b–j, paratypes. (p. 322)

13–16—Bathyuriscidella spinulosa Rasetti, n. sp., ×3. *13,* Cranidium; Laval U. 460a, holotype. *14,* Another cranidium. *15, 16,* Pygidia; Laval U. 460b–d, paratypes. (p. 323)

17–19—Bathyuriscidella longicauda Rasetti, n. sp. *17,* Cranidium, ×3; Laval U. 464a, holotype. *18,* Pygidium, ×2. *19,* Small cranidium with seven thoracic segments, ×6; Laval U. 464b–c, paratypes. (p. 326)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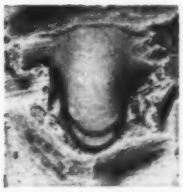
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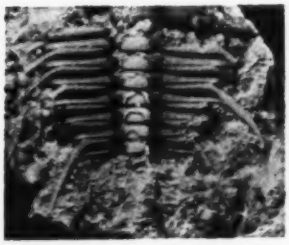
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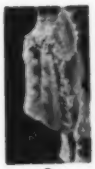
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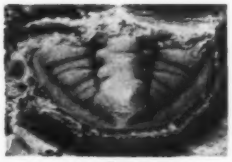
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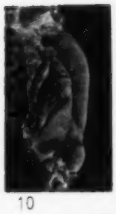
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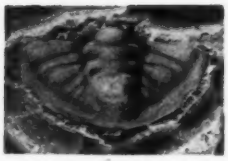
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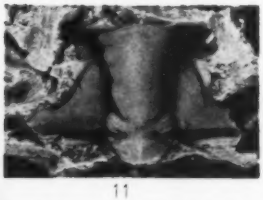
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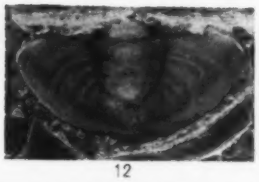
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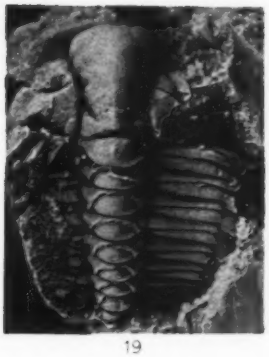
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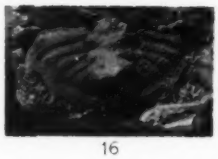
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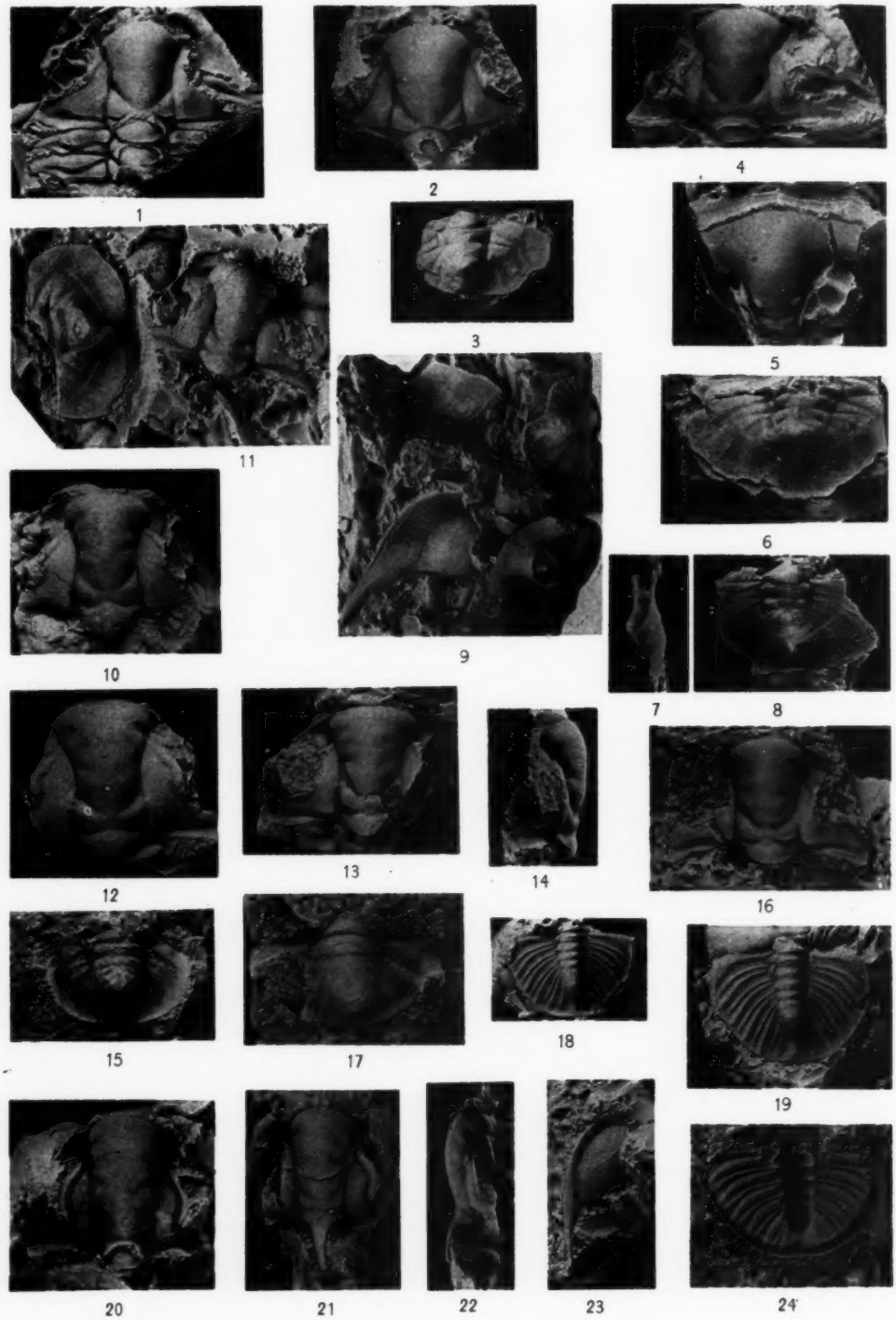
Rasetti, Quebec Middle Cambrian Trilobites



Rasetti, Quebec Middle Cambrian Trilobites

than in *B. socialis*, with a wide, poorly defined, slightly concave border. Two pairs of pleural furrows and interpleural grooves faintly impressed.

Length of largest cranidium 10 mm. Surface smooth.

Boulders M-8 and M-20 (holotype from the former).

Holotype and paratypes.—Laval University nos. 462a–v.

Bathyuriscidella obliqua
Rasetti, n. sp.
Plate 48, figures 1–3

Known from several cranidia and pygidia.

Glabella approximately as in *B. socialis*, moderately expanded in the anterior third, and also more gradually backward in the posterior portion; narrowest in the middle. Glabellar furrows about equally impressed as in *B. socialis*, but occupying a more advanced position. Frontal outline of the glabella rounded, extending farther forward than the border at the sides. Occipital furrow and ring as in *B. socialis*. Palpebral lobes more anterior in position than in *B. socialis*, obliquely placed, close to the glabella at their anterior ends. Posterior limbs wide, triangular. Anterior branch of facial suture very short, directed forward and slightly outward. Posterior branch almost perfectly straight.

Thoracic segments characterized by the peculiar course of the pleural furrows. These start from the anterolateral angle of the pleura, are first directed backward, thus approaching the posterior margin of the pleura, then curve forward. The pleura are rather suddenly tapered distally beyond the geniculation. The furrow on the first pleuron has a different course from the others, starting at the middle instead of from the anterior angle. Apparently one or more of the segments had an axial spine, because there is a separate segment showing it. However, other segments preserved have no spine, hence this seems to have been a feature of one or a few segments only.

Pygidium having some of the features of those of *B. socialis* and *B. amplicauda*. Axis as in *B. socialis*, occupying two-thirds of the length, followed by a postaxial ridge that reaches the margin. Pleural lobes as large in proportion to the axis as in *B. socialis*, but with smaller pleural platforms and a much wider, concave border defined by an indistinct marginal furrow. Posterior margin of pygidium with a definite mesial notch. Two faint, narrow pleural furrows and two interpleural grooves extend across the marginal furrow, suddenly changing their direction backward in crossing it.

Surface smooth. Length of largest cranidium 9 mm.

Boulder M-12, Métis, associated with *Hemirhodon convexifrons*.

Holotype and paratypes.—Laval University nos. 463a–e.

Explanation of Plate 48

The test is preserved in all the figured specimens unless otherwise indicated.

Figs. *1–3—Bathyuriscidella obliqua* Rasetti, n. sp. *1*, Cranidium with two thoracic segments, ×2; Laval U. 463a, holotype. *2*, Smaller cranidium, ×3. *3*, Pygidium, ×2. Laval U. 463b–c, paratypes. (p. 325)

4–9—Bathyuriscidella amplicauda Rasetti, n. sp. *4*, Cranidium, ×2; Laval U. 462a, holotype. *5*, Hypostoma, ×3. *6*, Pygidium, ×2. *7, 8*, Side and top views of another pygidium, ×2. *9*, Free cheek, hypostoma and pygidium, ×2. Laval U. 462b–e, paratypes. (p. 324)

10–16—Bathyuriscidella expansa Rasetti, n. sp. *10*, Cranidium, ×2; Laval U. 461a, holotype. *11*, Cranidium and pygidium, ×2. *12*, Cranidium, ×2. *13, 14*, Top and side views of another cranidium, ×2. *15*, Pygidium somewhat different from the typical form, associated with the preceding cranidium in boulder M-24, ×2. *16*, Slightly variant cranidium from boulder G-36, ×3. Laval U. 461b–f, paratypes. (p. 324)

17—Albertella? sp. undet. Pygidium, ×5; Laval U. 475. (p. 331)

18–23—Orriella gaspensis Rasetti, n. gen., n. sp. *21, 22*, Top and side views of cranidium, ×2; Laval U. 472a, holotype. *18, 19*, Pygidia, ×2. *20*, Small cranidium, ×4. *23*, Free cheek, ×2. Laval U. 472b–e, paratypes. (p. 329)

24—Bathyuriscus sp. undet. Impression of pygidium, ×2. Laval U. 458a. (p. 322)

BATHYURISCIDELLA LONGICAUDA
Rasetti, n. sp.
Plate 47, figures 17–19

Known from several cranidia and associated pygidia, and a small specimen preserving the head and part of the thorax.

Glabella rather strongly expanding forward in the anterior half, although not quite as much as in *B. expansa*. Four pairs of glabellar furrows clearly visible. Occipital ring with a small node. There is an exceedingly narrow border in front of the glabella, lacking in all other species of the genus. Fixed cheeks about one-third the glabellar width; palpebral lobes as large as in *B. socialis*, but occupying a more posterior position. Posterolateral limbs narrow and long as in *B. amplicauda*, apparently without intergenal spine.

Thorax of the same type as in *B. socialis*. The ends of the pleura are not preserved and hence it is not known whether some of them have longer spines.

Pygidium considerably different from all others of the genus, being much longer and narrower. Axis occupying slightly more than half the length, elevated, slightly conical, with two furrows besides the articulating furrow and a terminal section. Pleural lobes depressed, slightly concave. Anterior margin curving immediately backward, giving the whole pygidium a cordiform shape. Two pleural furrows and one interpleural groove very faint, curving backward and assuming a longitudinal course.

Surface of cranidium very finely granulated, of pygidium apparently smooth.

Length of largest cranidium 10 mm.; length of pygidium 9 mm., width 10 mm.

This species is placed in the genus because of the extreme similarity of the cranidium to that of *B. expansa*, while the pygidium, although much more elongated than in that species, does not possess an essentially different structure. The present form differs only in minor details from *Bathyuriscus* (*Poliella*) *probus* Walcott from the Marjum formation of Utah. Walcott was uncertain about the generic assignment of his species. Resser transferred it to *Clavaspidella* (in which he included *Athabaskia*) but remarked that the species was at the limit of the genus because of the peculiar pygidium. The writer believes that the two species agree better with *Bathyuriscidella* than with any other of the above-mentioned genera.

Probably related to the present one is a species from the Rockledge conglomerate of Vermont, represented only by pygidia and described by Raymond as *Calvinella obsoleta*. Comparison of casts of Raymond's types with the pygidium of the present species shows that they are almost identical. Both from the shape of these pygidia and from the stratigraphic position it is obvious that Raymond's species has nothing to do with *Calvinella*. Raymond (1937, p. 1137) states that his specimens were collected from the pebbles in a loose block of Rockledge conglomerate, the same that yielded *Hemirhodon schucherti*. The association of the present species with *Hemirhodon convexifrons* confirms the writer's assignment of Raymond's pygidium.

Boulder G-6, Grosses Roches, associated with large numbers of fragments of *Hemirhodon convexifrons*.

Holotype and paratypes.—Laval University nos. 464a–g.

Genus CORYNEXOCHIDES
Rasetti, n. gen.

Small trilobites with a rather flat shield tapering from a large cephalon to a relatively small pygidium, probably with seven thoracic segments in the genotype.

Glabella more or less strongly expanded in the frontal portion, reaching the front margin of the head. Glabellar furrows generally shallow. Occipital ring wide, in some species extended into a spine. Brim and border absent in front of the glabella; of very limited extent and poorly differentiated from each other at the sides. Palpebral lobes of medium length, fairly distant from the glabella. Posterior limbs of medium length, rounded at the end.

Pygidium small, transverse, with an elevated axis and depressed pleural lobes, with only the first segment well differentiated.

Genotype: *Corynexochides gregarius* Rasetti, n. sp.

Stratigraphic range: early Middle Cambrian.

Remarks.—This genus is erected for several species which are common in the early

Middle Cambrian boulders from Quebec. The cephalic features are similar to those of *Corynexochus* from the Middle Cambrian of the Atlantic province, and *Bonnaspis* from the Middle Cambrian of the Rocky Mountains. However, the entire shield presents considerable differences, as in the above-mentioned genera the pygidium is almost as large as the head, whereas in *Corynexochides* it is much smaller. The thoracic segments are characteristically bent backward at geniculation, a feature not present in the other genera, and the pygidium has a different structure.

The present genus is also a close relative of *Bathyuriscus*, *Poliella* and *Bathyuriscidella*, especially resembling immature forms of all these genera. Some of the species here assigned to *Corynexochides*, in particular those with longer palpebral lobes, are so similar to *Poliella* that one is uncertain whether they should not rather be placed in that genus. All this is additional evidence for the close interrelationship of the genera of the Bathyuriscidae.

CORYNEXOCHIDES GREGARIUS
Rasetti, n. sp.
Plate 46, figures 10–16

Known from a large number of associated fragments and two partially articulated shields.

Cranidium presenting the general features already indicated in the generic diagnosis. Glabella rapidly expanding forward in the anterior half. Posterior glabellar furrows very oblique, moderately impressed, almost joining mesially. Another pair short and shallow. In some specimens a trace of two more pairs can be distinguished. Occipital furrow straight, fairly deep. Occipital ring expanded backward, rounded, showing a small node. Ocular ridges very low, not very distant from the anterior margin, leaving little space for a rather undifferentiated brim and border. Palpebral lobes somewhat less than one-third the glabellar length, narrow, moderately curved, set off by a shallow palpebral furrow; their midpoint distant from the glabella about two-thirds of the glabellar width at the same level. Posterior limbs of average length, narrow, almost parallel-sided, narrowly rounded at the end. Anterior branch of facial suture approximately parallel to the side of the glabella; posterior branch directed almost straight outward behind the palpebral lobe, then gradually curving backward.

Free cheeks of moderate width, with a poorly defined, rather wide border, and moderately strong genal spines. Hypostoma of the typical bathyuriscid shape. Anterior wings strong, curving backward, sharply truncated at the end by the suture that separates them from the free cheeks, as in *Bathyuriscidella*. Anterior and posterior lobes completely separated by a pair of oblique furrows joined in the middle. Maculae well developed, just anterior to the furrow. Border developed around the posterior half of the hypostoma, narrow, extended into a pair of short spines at the level of the maculae.

Thorax known from seven segments attached to a pygidium and six segments attached to a cranidium. From a comparison of the shape of the segments in these two individuals it seems that the first-mentioned thorax is complete; certainly it cannot lack more than one segment. Axis strongly prominent, slightly tapered, occupying about one-fourth of the width. Pleura flat, bluntly terminated, bent backward rather than downward at geniculation, the rather sharp bend occurring gradually closer to the axis as one proceeds toward the back. Pleural furrows shallow, better impressed midway between the dorsal furrows and the end of the pleura, obsolete distally.

Pygidium twice wider than long. Axis prominent, tapered, occupying two-thirds of the length; with the articulating furrow and another shallow furrow. Pleura with little relief, slightly convex. Anterior outline obliquely truncated for about half its length; anterior angles sharp. Remaining outline forming a regular circular arc. First pleural furrow broad and shallow, two others short and even shallower. Border differentiated only because the pleural furrows do not extend across it. First interpleural groove unusually well marked, stronger distally, reaching the margin; in reality more a step than a groove. It appears as if the first pygidial segment were much less fused than the others; in fact it reproduces the exact structure of the last thoracic segment.

Surface of most of the shield smooth. An-

terior half of glabella with transverse ridges; surface of hypostoma with the same type of ornamentation.

Length of largest cranidium 5 mm. Length of largest pygidium 2.5 mm., width 4.8 mm. From the two partially articulated shields it results that the relative lengths of cephalon, thorax and pygidium are about 2.1 mm., 2.5 mm., and 0.8 mm.

Boulder M-23, Métis, where the species occurred in great numbers, associated with a species of *Kootenia*.

Holotype and paratypes.—Laval University nos. 465a–y.

Corynexochides bicensis
Rasetti, n. sp.
Plate 46, figures 23, 24

Known from numerous cranidia and a few pygidia.

Cranidium similar to that of *C. gregarius*, differing in the following characters. Glabella less convex, and somewhat less expanded in front. Brim at the sides of somewhat lesser extent, the anterior branch of the facial suture being closer to the glabella than in *C. gregarius*. An extremely narrow border extends in front of the glabella. Palpebral lobes somewhat longer than in the preceding species; fixed cheeks narrower.

The associated pygidium has the same general outline as in *C. gregarius*, but the first interpleural groove is not well marked as in that species. The pleura of the first segment extend somewhat farther outward than the remaining part of the pleural lobes.

Surface smooth. Length of the largest cranidium 3.5 mm.

Boulder B-13, Bic.

Holotype and paratypes.—Laval University nos. 466a–g.

Corynexochides sublaevis
Rasetti, n. sp.
Plate 46, figures 25, 26

Known from several cranidia.

Cranidium extremely similar to that of *C. bicensis;* hence it will be sufficient to point out the differences. The posterior glabellar furrows are much more oblique than in *C. gregarius* and *C. bicensis*, starting from the dorsal furrows and being almost parallel to them. The other glabellar furrows are indistinct. An extremely narrow border extends in front of the glabella as in *C. bicensis*.

Surface smooth. Length of largest cranidium 3.4 mm.

Boulder L-4, Ville Guay.

Holotype and paratypes.—Laval University nos. 467a–e.

Corynexochides laevigatus
Rasetti, n. sp.
Plate 46, figures 19–22

Known from several cranidia and a few associated pygidia.

Cranidium very smooth, the dorsal furrow being shallow on the other surface, the occipital furrow almost indistinct, the glabellar furrows entirely obsolete. Glabella moderately expanded, less than in *C. gregarius*. Undifferentiated brim and border at the sides of the glabella narrower than in *C. gregarius;* no border in front. Palpebral lobes as long as in that species, but closer to the glabella, giving the fixed cheeks only one-half of the glabellar width. Palpebral furrows very shallow. Posterior limbs relatively short and broad, rounded.

Pygidium identical with that of *C. bicensis*.

Surface of test smooth. Length of largest cranidium 4.5 mm.

Boulders O-34 and L-5, Island of Orléans and Ville Guay (holotype from the former).

Holotype and paratypes.—Laval University nos. 468a–h.

Corynexochides longicollis
Rasetti, n. sp.
Plate 46, figures 17, 18

Known from several cranidia and associated pygidia.

Cranidium very similar to that of *C. laevigatus*, although the dorsal furrow is somewhat better impressed and the occipital furrow clearly distinguishable. The occipital ring extends into a long, flat, rounded spine. The palpebral furrow is fairly well impressed. The brim at the sides of the glabella is somewhat wider than in *C. laevigatus*.

The associated pygidium is extremely similar to those of *C. bicensis* and *C. laevigatus*, possibly differing in the slightly larger area occupied by the axis.

Length of largest cranidium (inclusive of the occipital spine) 7 mm. Surface smooth.

Boulder G-46, Grosses Roches.

Holotype and paratypes.—Laval University nos. 469a–h.

CORYNEXOCHIDES LATIFRONS
Rasetti, n. sp.
Plate 46, figures 8, 9

Known from several cranidia, one of which has three thoracic segments attached.

The general cranidial features are those of *C. gregarius*, but there are several important differences. The glabella expands more strongly in the anterior half, its maximum width at the front being twice the width of the rear portion. The palpebral lobes are shorter and the width of the fixed cheeks equals the width of the posterior portion of the glabella. The occipital ring is much more expanded backward; one can say that it forms a stout, rounded spine. The posterior branch of the facial suture curves backward much closer to the palpebral lobe, owing to the more outward position of the latter. Hence the posterior limbs are proportionately wider and shorter. The thoracic segments available are identical with those of *C. gregarius*.

Length of the largest cranidium 3.6 mm. Surface of test smooth.

Boulder M-3, Métis.

Holotype and paratypes.—Laval University nos. 470a–d.

CORYNEXOCHIDES CONSTRICTUS
Rasetti, n. sp.
Plate 46, figures 27–28

Known from a few cranidia.

Glabella of moderate convexity, defined by a fairly well-impressed dorsal furrow, expanded in front somewhat less than in *C. gregarius*. Two pairs of glabellar furrows, short and rather shallow. Occipital furrow rather well impressed, occipital ring simple. There is an exceedingly narrow border in front of the glabella. Brim at the sides reduced to a lesser area than in all other described species of the genus, the anterior branch of the facial suture being very close to the dorsal furrow. Palpebral furrow well impressed; palpebral lobes longer than in *C. bicensis*. Posterior limbs relatively narrow.

Surface smooth. Length of largest cranidium 4.5 mm.

Boulder L-9, Ville Guay.

Holotype and paratypes.—Laval University nos. 471a–e.

Genus ORRIELLA Rasetti, n. gen.

Glabella strongly prominent, long and narrow, expanding forward, reaching the anterior margin of the head. Glabellar furrows shallow. Occipital ring with a strong spine in the genotype. Brim and border developed only at the sides. Palpebral lobes about half the glabellar length, narrow, curved, almost touching the glabella at their anterior ends. Posterior limbs long and narrow. Free cheeks with wide ocular platforms, narrow border, and slender genal spines.

Pygidium large, probably almost as large as the cephalon. Axis narrow, of five or six segments, slightly tapered, occupying two-thirds of the length, extended into a post-axial ridge. Pleural lobes flat; pleural furrows and interpleural grooves about equally deep, the latter narrower. Grooves well distinct from the furrows proximally, not almost confluent as in *Bathyuriscus*. Furrows and grooves reaching the margin, owing to lack of a border.

Genotype: *Orriella gaspensis* Rasetti, n.sp.

Stratigraphic range: late Middle Cambrian.

Remarks.—This genus is intermediate between *Bathyuriscus* and *Orria*. It differs from *Bathyuriscus* chiefly in the much longer eyes, lack of a border in front of the glabella, presence of an occipital spine, and the already noted characters of the pygidium. The chief differences from *Orria* are the deeper dorsal furrow and more prominent glabella, better developed brim at the sides of the glabella, and lesser length and different shape of the posterior limbs. The pygidium of *Orria elegans* has almost exactly the same structure as that of *Orriella gaspensis*, but the latter has fewer segments.

ORRIELLA GASPENSIS Rasetti, n. sp.
Plate 48, figures 18–23

Known from numerous cranidia and associated pygidia.

Glabella strongly elevated above the fixed cheeks, strongly convex transversely, less and about uniformly convex longitudinally, expanding forward, almost straight-sided. Four shallow glabellar furrows, all about

equally impressed. Occipital furrow shallow; occipital segment extended into a long, slender, curved spine. Anterior pits well impressed. Brim and rim developed only at the sides, occupying a small area because the anterior branch of the facial suture is short and not very distant from the glabella. Palpebral lobes long and narrow, straight and oblique for the anterior half, then curving inward. Palpebral furrow well impressed. Maximum width of the fixed cheeks less than half the glabellar width. Posterior limbs long and narrow, parallel-sided, with a wide furrow. Free cheeks with a wide ocular platform and a narrow, slightly upturned border.

Pygidium with axis occupying about one-fifth of the width and two-thirds of the length. Four axial furrows and the articulating furrow well impressed. Postaxial ridge low, reaching the margin. Pleural lobes slightly concave, lacking a border. Five pairs of pleural furrows and as many interpleural grooves impressed. The ridge between each interpleural groove and the succeeding pleural furrow widens toward the margin; this character, coupled with the fact that the furrows and grooves reach the edge of the pleural lobes, gives the pygidium a peculiar aspect.

Surface smooth except for irregular anastomosing ridges on the ocular platforms.

Length of largest cranidium 13 mm. Length of largest pygidium 8.5 mm., width 11 mm.

Boulder G-31, Grosses Roches, associated with *Bathyuriscidella socialis*.

Holotype and paratypes.—Laval University nos. 472a–v.

Genus HEMIRHODON Raymond, 1937

HEMIRHODON CONVEXIFRONS
Rasetti, n. sp.
Plate 52, figures 7, 8

Known from a large number of fragments associated in one pebble.

Glabella reaching the front end of the head, strongly expanded forward, with somewhat concave sides; frontal portion probably extending somewhat in advance of the general outline of the cephalon. Glabella weakly convex longitudinally for most of its length, except near the anterior end where it attains a strong convexity and drops vertically to the anterior margin. Two pairs of glabellar furrows barely indicated by extremely shallow, wide depressions. Occipital furrow shallow. Occipital segment flat, without spine or node. Brim confined to the sides of the glabella. Palpebral lobes very small, short, obliquely placed so that while the anterior end is very close to the glabella, the posterior end is at a somewhat greater distance from it. Ocular ridges indistinct. The fixed cheeks slope downward with little change in slope from the glabella; the dorsal furrows are shallow. Anterior pits indistinct. Posterior limbs large, with a very shallow marginal furrow. Facial sutures diverging in front of the eyes, about parallel to the sides of the expanding glabella, then curving inward and meeting the edge of the glabella at some distance from the median line. Posterior branch directed outward and backward, reaching the posterior margin with an almost even curvature.

Hypostoma with a convex anterior outline paralleling that of the glabella, to which it must have been directly attached, the ros-

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EXPLANATION OF PLATE 49

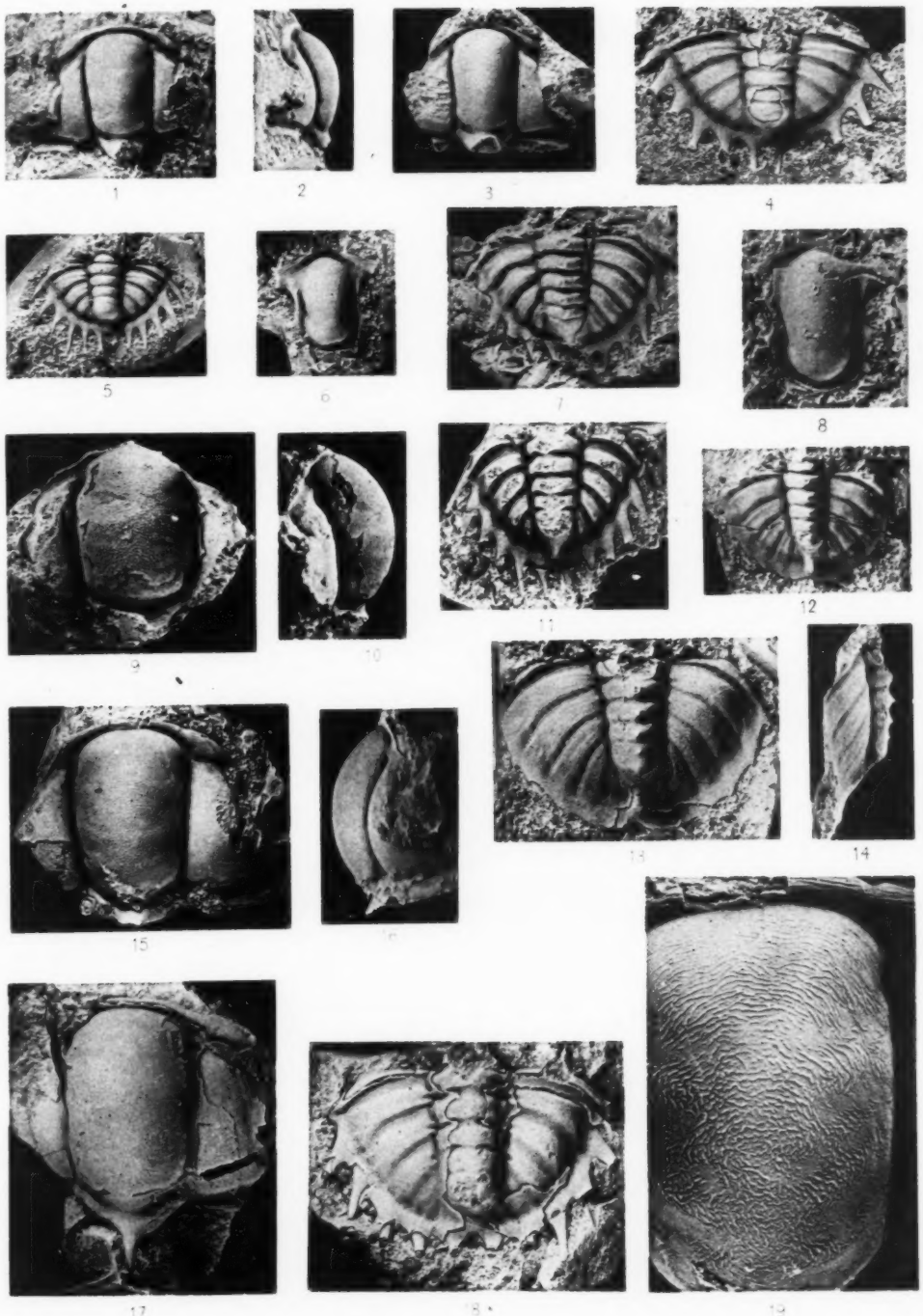
The test is preserved in all the figured specimens unless otherwise indicated.

FIGS. *1–6*—*Kootenia elongata* Rasetti, n. sp. *1, 2*, Top and side views of cranidium, ×3; Laval U. 482a, holotype. *3*, Another cranidium, ×3. *4*, Pygidium, ×2. *5*, Smaller pygidium, ×3. *6*, Hypostoma, ×3. Laval U. 482b–e, paratypes. (p. 332)

7–11—*Kootenia sulcata* Rasetti, n. sp., ×3. *7*, Pygidium with test preserved on the right pleural lobe; Laval U. 483a, holotype. *8*, Hypostoma, *9, 10*, Top and side views of incomplete cranidium. *11*, Exfoliated pygidium. Laval U. 483b–d, paratypes. (p. 332)

12–14—*Kootenia rotundata* Rasetti, n. sp., ×2. *12*, Pygidium; Laval U. 486b, paratype. *13, 14*, Top and side views of pygidium; Laval U. 486a, holotype. (p. 334)

15–19—*Kootenia billingsi* Rasetti, n. sp. *15, 16*, Top and side views of cranidium, ×1.5; Laval U. 484a, holotype. *17*, Another cranidium, ×1.5. *18*, Partly exfoliated pygidium, ×1.5. Laval U. 484b–c, paratypes. *19*, Glabella of holotype cranidium, ×4, showing surface ornamentation. (p. 333)



Rasetti, Quebec Middle Cambrian Trilobites

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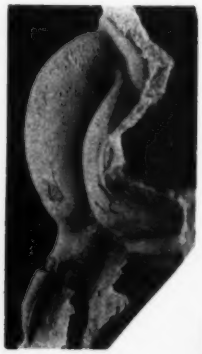
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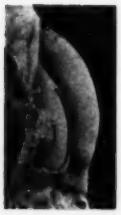
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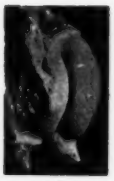
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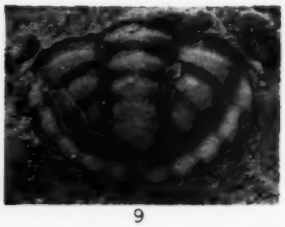
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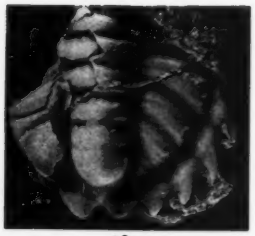
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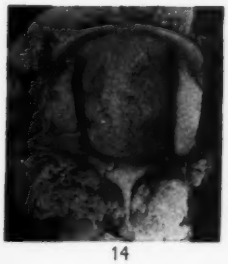
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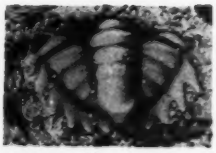
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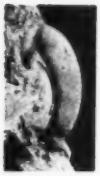
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Rasetti, Quebec Middle Cambrian Trilobites

trum being fused with the hypostoma. Anterior wings not well preserved. Anterior lobe uniformly convex, separated from the posterior lobe by a pair of oblique furrows that meet mesially, although becoming very shallow. Posterior lobe with a convex border separated by a distinct marginal furrow. No spines at the sides of the rounded posterior lobe.

Thoracic segments rather flat. Pleura with a broad, shallow furrow; slightly bent backward and downward at geniculation.

Pygidium of the typical semicircular shape, with little relief. Anterior angles widely rounded. Axis low, showing four segments separated by shallow furrows and a terminal section; reaching less than two-thirds of the pygidial length and continued into a low post-axial ridge. Pleural lobes with very little relief, slightly concave marginally. Four pairs of pleural furrows and three pairs of interpleural grooves, about equally impressed, become shallower and broader distally and die out before crossing the concave marginal area. Doublure almost as wide as one-half of the pygidial length.

Test of all parts of the shield very thin. Surface smooth.

Length of the largest cranidium 29 mm.; length of largest pygidium 29 mm., width 42 mm.

This species is so similar to *H. viator* Raymond, described from the Rockledge conglomerate of Vermont, that the writer hesitated before describing it as a new species. The only significant difference seems to be the considerably greater convexity of the glabella in the new species. This form is also very close to two early Upper Cambrian species recently described by the writer. However, in the present case the association with species of *Bathyuriscidella* definitely suggests that the species is of Middle Cambrian age.

Boulder G-5, Grosses Roches.

Holotype and paratypes.—Laval University nos. 473a–h.

Family ZACANTHOIDIDAE Swinnerton

Genus ZACANTHOIDES Walcott, 1888

ZACANTHOIDES sp. undet.

Plate 52, figures 1–6

Cranidia and pygidia of *Zacanthoides* occur in several boulders, but each one yielded only a few fragments and it was not possible to match heads and tails with any certainty. For this reason, and also because it seems difficult to evaluate the distinguishing features of several described species of *Zacanthoides*, the material is figured without any assignment of specific names. The illustrated fragments may represent more than one species.

Boulders L-4, L-8 and L-9, Ville Guay.

Figured specimens.—Laval University nos. 474a–e.

Genus ALBERTELLA Walcott, 1908

ALBERTELLA ? sp. undet.

Plate 48, figure 17

A single pygidium is tentatively assigned to *Albertella*. Although its systematic position is uncertain because of lack of an associated cranidium, this specimen is considered worth illustrating because it suggests the interesting possibility that this western genus may be represented in Quebec.

Pygidium twice wider than long. Axis slightly tapered, occupying most of the length, with one furrow besides the articu-

EXPLANATION OF PLATE 50

The test is preserved in all the figured specimens unless otherwise indicated.

FIGS. *1–4—Kootenia quebecensis* Rasetti, n. sp. *1, 2,* Top and side views of cranidium, ×3; Laval U. 485a, holotype. *3, 4,* Pygidia, ×2; Laval U. 485b–c, paratypes. (p. 333)

5–9—Kootenia parallela Rasetti, n. sp. *5, 6,* Top and side views of cranidium, ×4; Laval U. 487a, holotype. *7,* Cranidium, ×2.5. *8, 9,* Pygidia, ×2.5. Laval U. 487b–d, paratypes. (p. 335)

10–13—Kootenia gaspensis Rasetti, n. sp. *10, 11,* Side and top views of cranidium, ×2.5; Laval U. 488a, holotype. *12,* Exfoliated pygidium, ×2.5. *13,* Small pygidium, ×5. Laval U. 488b–c, paratypes. (p. 335)

14–20—Kootenia ellsi (Walcott). *14, 15,* Top and side views of exfoliated cranidium, ×2. USNM 18450, lectotype. *16,* Exfoliated pygidium, ×2; USNM 18450, paratype. *17, 18,* Pygidia, ×4; Laval U. 489a–b, plesiotypes. *19, 20,* Top and side views of small cranidium, ×4; Laval U. 489c, plesiotype. (p. 336)

lating furrow, and a terminal unsegmented section. Pleural lobes flat, with very faint furrows, and a narrow, poorly defined, slightly concave border. The marginal spines seem to be an extension of the first two pleural segments together; they seem to have been directed outward and backward, and also somewhat upward. The spines are broken at the base and their length is unknown. Surface smooth.

This pygidium differs from those of the described species of *Albertella* chiefly in its greater relative width.

Boulder L-8, Ville Guay. The associated species, especially *Pagetia ellsi*, indicate an early Middle Cambrian age.

Figured specimen.—Laval University no. 475.

Family DORYPYGIDAE Kobayashi
Genus KOOTENIA Walcott, 1889

Species of *Kootenia* are common in the Middle Cambrian boulders. Usually only one species occurred in each boulder, allowing a reasonably safe assignment of cranidium and pygidium to the same species. Only those species are described for which both shields are known, excepting one case where the pygidium has unusual characters and cannot be confused with other species.

All the species of *Kootenia* whose types are preserved in the U. S. National Museum, representing almost the totality of the described species, were studied and compared with the forms in the writer's collection. The latter could not be identified with any of the species described from other localities. A significant comparison could not be established with a few described species that are too poorly represented for the determination of their specific characters.

A Lower Cambrian species of the genus described by the writer from conglomerate boulders (Rasetti, 1948) can be readily distinguished because the pygidium has seven pairs of marginal spines, whereas all the Middle Cambrian species here discussed never have more than six.

KOOTENIA ELONGATA Rasetti, n. sp.
Plate 49, figures 1–6

Known from numerous cranidia, free cheeks, hypostomas and pygidia.

Glabella of moderate convexity, relatively long and narrow, straight-sided, slightly expanding toward the front, unfurrowed. Occipital ring extended into a spine of unknown length. Border in front of the glabella very narrow; brim at the sides confined to a narrow depression between the border and the ocular ridges. Ocular ridges wide and low. Palpebral lobes faintly curved, directed longitudinally, one-third the glabellar length. Maximum width of the fixed cheeks three-fifths the glabellar width at the same level. Posterior limbs as usual in the genus, with a deep marginal furrow.

Pygidial axis slightly tapered, with three distinct furrows besides the articulating furrow, and a fourth furrow impressed on the cast of the inner surface, without axial nodes. Pleural lobes with four pairs of furrows; first interpleural groove narrow but distinct throughout, second impressed proximally, others indistinct. Marginal furrow broad and shallow; pleural furrows not extended across the border. Six pairs of slender marginal spines, of about equal size, about one-third the pygidial length.

Surface smooth or very finely granulated.

Most of the shields from the typical boulder are small, but the largest pygidium, 7 mm. in length and 15 mm. in width, indicates that the species attains a fairly large size.

Of all described species, *K. gracilis* Resser has the pygidium which most resembles that of the present form. In the new species, however, the pygidium is less convex and proportionately wider and shorter; the marginal spines are less slender. The cranidium of *K. elongata* is characterized by a proportionately narrower and longer glabella than in *K. gracilis* and in almost all other described species of the genus.

Boulder L-4, Ville Guay.

Holotype and paratypes.—Laval University nos. 482a–q.

KOOTENIA SULCATA Rasetti, n. sp.
Plate 49, figures 7–11

Known from several cranidia and associated pygidia.

Cranidia imperfectly preserved. Glabella strongly convex, expanding toward the front up to the level of the anterior pits, in front of which it is markedly constricted. Glabellar furrows indistinct. Occipital ring not well

preserved. Border and brim apparently of average extent for the genus. Fixed cheeks slightly more than half the glabellar width at the level of the midpoint of the palpebral lobes. Palpebral lobes apparently somewhat less than one-third the glabellar length.

Pygidial axis slightly tapered, showing five segments and a terminal section extended into a post-axial ridge that reaches the margin. First four axial furrows very strong even on the upper surface. There is a node or spine on each of the five segments. Pleural lobes with five pairs of strong pleural furrows. Interpleural grooves almost indistinct. Marginal furrow broad and shallow; border extended into six pairs of spines, of about equal size, approximately equidistant, directed straight backward, sharply pointed. Length of spines about one-fourth the pygidial length.

Surface of prominent parts of cranidium and pygidium rather strongly granulated. Granules changing to transverse ridges on anterior portion of glabella.

Length of largest cranidium 9 mm., length of largest pygidium 12 mm., width 18 mm.

This species differs from all others described in the characters of the pygidium, especially the strongly annulated axis with axial spines, and the deep pleural furrows. These characters are found in several Lower Cambrian species which, however, have seven pairs of marginal spines.

Boulder O-34, Island of Orléans.

Holotype and paratypes.—Laval University nos. 483a–n.

KOOTENIA BILLINGSI Rasetti, n. sp.
Plate 49, figures 15–19

Known from numerous cranidia and associated pygidia.

Glabella rather strongly convex, straight-sided, slightly expanding toward the front, slightly constricted in front of the anterior pits. Glabellar furrows obsolete. Occipital ring narrow, extended into a slender spine, turned up at an angle of about 30 degrees, probably about one-third the glabellar length when complete. Border in front of glabella narrow; somewhat wider at the sides, poorly differentiated from the brim which occupies a pair of small depressions between the border and the ocular ridges. Fixed cheeks about one-half the glabellar width; palpebral lobes about one-third the glabellar length. Posterior limbs of usual shape, deeply and broadly furrowed.

Pygidial axis subcylindrical, rounded posteriorly. Four segments and a terminal section are separated by increasingly shallow furrows. Faint axial nodes on the first segments. Marginal furrow broad, of moderate depth. Six marginal spines, equidistant and of equal size, slender, subcylindrical; the three posterior pairs directed straight backward, the front pairs slightly outward. Length of spines between one-third and one-half the pygidial length.

Surface of glabella with fine ridges arranged in irregular concentric pattern. Smoother areas indicate the position of the obsolete glabellar furrows. Prominent parts of pygidium finely granulated.

Length of largest cranidium (exclusive of occipital spine) 24 mm. Length of largest pygidium 17 mm., width 27 mm.

This large species is not rare in the boulders of the Ville Guay conglomerate. The pygidium figured by Billings (1865, p. 405, fig. 384) as *Dikelocephalus* sp. probably belongs to this species.

The described species that approach the present one most closely seem to be *K. dawsoni* (Walcott), the genotype, and *K. idahoensis* Resser. *K. dawsoni* has strong nodes or axial spines on the pygidium, and the marginal spines appear to be shorter. In *K. idahoensis* the marginal spines are shorter and directed more straight backward.

Boulders L-16 and L-7, Ville Guay (holotype from the former).

Holotype and paratypes.—Laval University nos. 484a–n.

KOOTENIA QUEBECENSIS Rasetti, n. sp.
Plate 50, figures 1–4

Known from several cranidia and associated pygidia.

Glabella strongly convex transversely and longitudinally, straight-sided, practically of even width, unfurrowed. Occipital ring of moderate width; occipital spine strong, starting at an angle of about 45° and then curving downward; its length almost one-half the glabellar length. Border moderately wide in front of the glabella, somewhat widened at the sides; brim reduced to a pair

of shallow furrows between the border and the ocular ridges. Ocular ridges wide, fairly prominent, directed very obliquely backward. Palpebral lobes moderately wide, rather strongly curved, separated by well-impressed palpebral furrows. Palpebral lobes situated considerably back of the glabellar midpoint; less than one-third the glabellar length. Posterior limbs as usual in the genus.

Pygidium with strongly prominent, subcylindrical axis. Four segments and a terminal section are separated by increasingly shallow furrows. Apparently no axial nodes or spines. Pleural lobes with four pairs of pleural furrows, shallow except the first, and traces of interpleural grooves. Marginal furrow broad and very shallow. Six pairs of marginal spines, the second, third and fourth pairs strongest, the first and fifth pairs somewhat smaller, the sixth pair considerably thinner and shorter, close together. All spines directed slightly upward; first to third pairs directed less and less outward, fourth to sixth pairs almost straight backward. Spines subcylindrical, sharply pointed; the longest about two-thirds the pygidial length.

Surface of glabella with rather strong, elevated granules that become transverse ridges on the anterior portion. Border transversely striated. Fixed cheeks with elevated granules. The pygidia preserve little of the test, but enough to show that the elevated parts are finely granulose.

Length of largest cranidium 12 mm.; length of largest pygidium 12 mm., width 19 mm.

This species is almost identical with *K. quadriceps* (Hall and Whitfield) as far as the pygidium is concerned, but the glabella is much more convex. Another closely related species is *K. mathewsi* Resser, but the position of the two posterior pairs of marginal spines is different.

Boulders M-25, Métis and O-36, Island of Orléans (holotype from the former).

Holotype and paratypes.—Laval University nos. 485a–m.

KOOTENIA ROTUNDATA Rasetti, n. sp.
Plate 49, figures 12–14

Although known only from pygidia, this form is described because of its unusual characters.

Pygidial axis slightly tapered, occupying a lesser fraction of the pygidial length than in most species of the genus; extended into a postaxial ridge that reaches the margin. Axis composed of five segments and a terminal section; axial furrows narrow but well distinct. There are five axial nodes of decreasing size. Pleural lobes with five pairs of furrows, shallow except the first. Interpleural grooves barely indicated. Furrows dying out at some distance from the margin; marginal furrow and border hardly differentiated except by the flattening out of the marginal area of the pleural lobes. First marginal spine very small, pointed; second even smaller; third barely visible; following spines just represented by a faint waviness of the border. There is a distinct marginal notch corresponding to the postaxial ridge.

Surface with such fine granulations as to appear practically smooth.

Length of largest pygidium 13 mm., width 19 mm.

The pygidium of this species does not closely resemble those of any described spe-

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EXPLANATION OF PLATE 51

The test is preserved in all the figured specimens unless otherwise indicated.

FIGS. *1–4—Olenoides métisensis* Rasetti, n. sp. *1, 2,* Top and side views of a small cranidium, ×3; Laval U. 478a, holotype. *3, 4,* Exfoliated pygidia, ×1; Laval U. 478b–c, paratypes. (p. 337)

5–9—Olenoides convexus Rasetti, n. sp. *5, 6,* Top and side views of cranidium, ×3; Laval U. 479a, holotype. *7,* Portion of same cranidium, ×5, to show surface ornamentation. *8,* Exfoliated pygidium, ×2. *9,* Pygidium, ×2. Laval U. 479b–c, paratypes. (p. 338)

10–14—Olenoides foveolatus Rasetti, n. sp. *10, 11,* Top and side views of cranidium, ×1.5; Laval U. 480a, holotype. *12,* Partly exfoliated pygidium, ×1. *13,* Incomplete pygidium, ×1.5. *14,* Portion of pygidium, ×1. Laval U. 480b–d, paratypes. (p. 338)

15–17—Olenoides granulatus Rasetti, n. sp., ×5. *15, 16,* Top and side views of cranidium; Laval U. 477a, holotype. *17,* Pygidium; Laval U. 477b, paratype. (p. 337)

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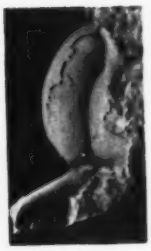
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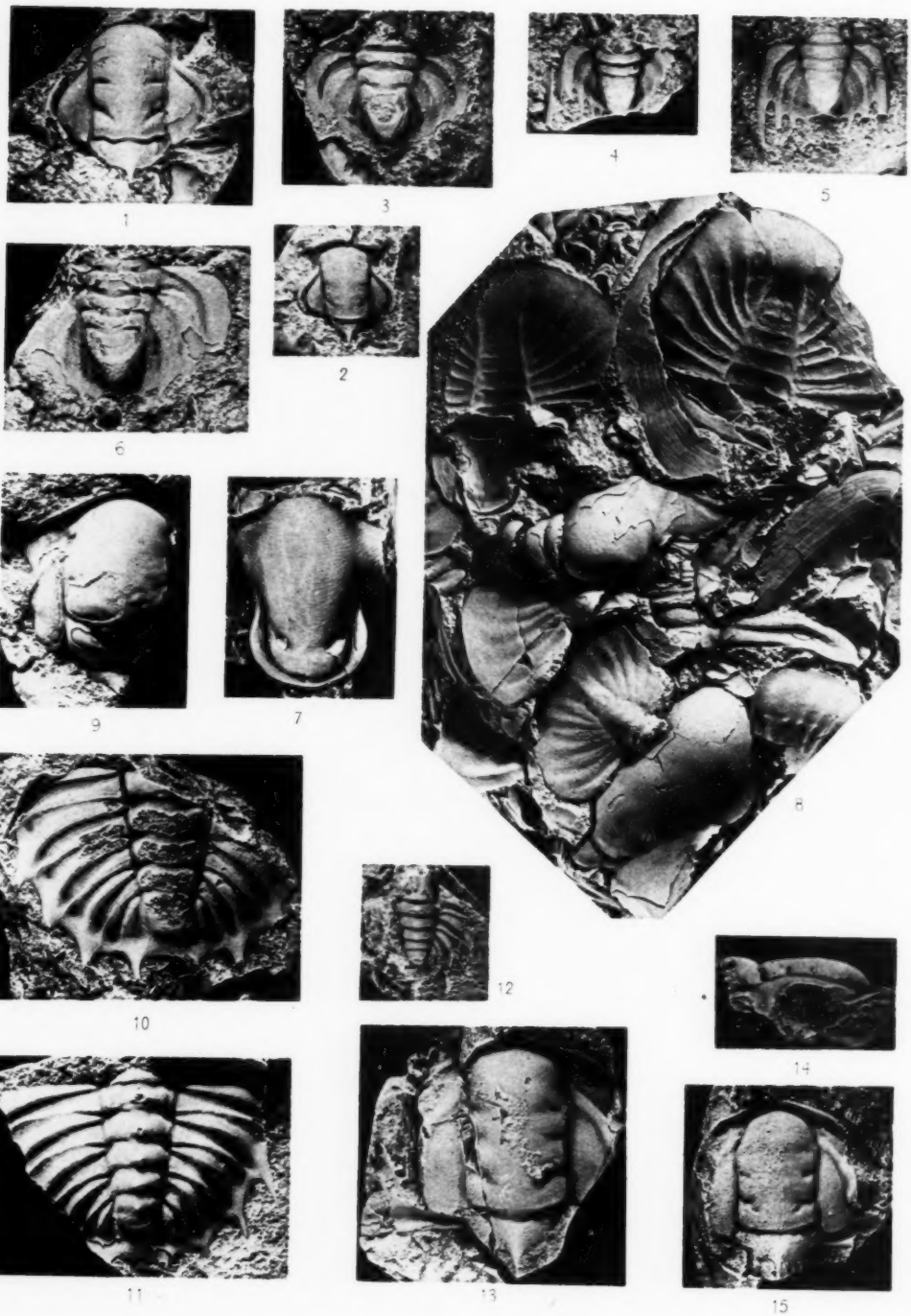
Rasetti, Quebec Middle Cambrian Trilobites



Rasetti, Quebec Middle Cambrian Trilobites

cies. The few forms in which the marginal spines are as reduced as in the present one, such as *K. romensis* Resser, have a longer axis and a more definite, convex border.

Boulder O-36, Island of Orléans.

Holotype and paratypes.—Laval University nos. 486a–e.

KOOTENIA PARALLELA Rasetti, n. sp.
Plate 50, figures 5–9

Known from several cranidia and associated pygidia.

Glabella weakly convex, parallel-sided, unfurrowed, somewhat constricted in front of the anterior pits which are well impressed. Occipital ring extended into a triangular, sharply pointed, horizontal spine of no great length. Border in front of glabella of moderate width, somewhat expanded at the sides. Brim at the sides limited to a shallow furrow between border and ocular ridges. Fixed cheeks about one-half the glabellar width. Palpebral lobes somewhat less than one-third the glabellar length, moderately curved. Posterior limbs of usual shape, deeply furrowed.

Pygidium with subcylindrical axis, showing four segments and a terminal section; axial furrows increasingly shallow, the last poorly impressed even on the inner surface. A short postaxial ridge reaches the margin. Pleural lobes with four furrows, shallow except the first, even on the cast of the interior, probably still shallower on the outer surface. Marginal furrow broad. Border extended into six pairs of spines. First pair short, sharply pointed, second pair rather blunt, the four following pairs rounded, extending very little beyond the general outline of the shield.

Surface of glabella covered with granules arranged in irregular transverse lines. The pygidia are mostly exfoliated, but fragments of test preserved show little surface ornamentation.

Length of largest cranidium 8 mm.; length of largest pygidium 9 mm., width 13 mm.

The pygidium of this species is so similar to that of *K. serrata* (Meek) that if this had been the only known part of the shield the writer would not have been induced to make a new species. However, if the cranidium is correctly assigned, it differs from that of Meek's species in that the glabella is parallel-sided instead of slightly expanded toward the front. A cranidium is chosen as the holotype, hence the name will remain attached to this part of the shield if cranidium and pygidium have been incorrectly assigned to one species.

Boulders L-3, Ville Guay, and O-36, Island of Orléans (holotype from the latter).

Holotype and paratypes.—Laval University nos. 487a–i.

KOOTENIA GASPENSIS Rasetti, n. sp.
Plate 50, figures 10–13

Known from several cranidia and associated pygidia.

Glabella of moderate convexity, very slightly expanded toward the front, straight-sided, unfurrowed, very slightly constricted by the anterior pits, which are well impressed. Occipital ring extended into an upturned spine of unknown length. Border in front narrow, somewhat expanded at the sides. Fixed cheeks one-half the glabellar width; palpebral lobes slightly oblique, moderately curved, about one-third the gla-

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EXPLANATION OF PLATE 52

The test is preserved in all the figured specimens unless otherwise indicated.

FIGS. *1–6—Zacanthoides* sp. undet. *1*, Cranidium, ×2. *2*, Smaller cranidium, ×3. *3–6*, Pygidia, ×3. Possibly these specimens represent more than one species. Laval U. 474a–e. (p. 331)

7–8—Hemirhodon convexifrons Rasetti, n. sp. *7*, Exfoliated hypostoma, ×2; Laval U. 473b, paratype. *8*, Piece of limestone with many fragments, ×1, the cranidium at bottom being the holotype; Laval U. 473a. (p. 330)

9–11—Olenoides cf. *O. serratus* (Rominger). *9*, Cranidium, ×1.5. *10*, Pygidium, ×1.5. *11*, Pygidium, ×2. Laval U. 481a–c. (p. 339)

12–15—Olenoides brevispinus Rasetti, n. sp., ×2.5. *14*, *15*, Side and top views of cranidium; Laval U. 476a, holotype. *12*, Incomplete pygidium. *13*, Cranidium. Laval U. 476b–c, paratypes. (p. 336)

bellar length. Posterior limbs as usual in the genus, deeply furrowed.

Pygidium with slightly tapered, rounded axis and short postaxial ridge. Three axial furrows visible on the upper surface and four on the cast of the interior. No axial nodes or spines. Pleural lobes with four pairs of furrows, shallow except the first. First interpleural groove faintly impressed, others rather indistinct. Marginal furrow broad and shallow. Six pairs of marginal spines, the first pair slender, each successive pair shorter and less pointed, until those of the last pair are but rounded expansions enclosing the median marginal notch.

Surface of cranidium with granules having a tendency to become arranged in transverse lines; prominent parts of pygidium finely granulated.

Length of largest cranidium 6 mm.; length of largest pygidium 11 mm., width 15 mm.

The pygidium of this species, characterized by the short spines of the posterior pairs, is somewhat similar to that of *K. burgessensis* Resser. It is difficult to establish a close comparison because all the available material of that species is flattened in shale. The cranidium of *K. gaspensis* is typical of the average forms of the genus.

Boulder M-3, Métis.

Holotype and paratypes.—Laval University nos. 488a-l.

Kootenia ellsi (Walcott)
Plate 50, figures 14–20

Olenoides ellsi Walcott, 1890, U. S. Geol. Surv., 10th Ann. Rept., p. 642, text figs. 66a–g.
Kootenia ellsi (Walcott). Resser, 1937, Jour. Paleontology, vol. 11, p. 50.

Walcott gave a detailed description of this species. Two of the types are refigured, and the larger cranidium illustrated by Walcott is chosen as lectotype.

Cranidia and pygidia occurring in two of the boulders collected by the writer seem referable to this species. The pygidia are perfectly typical. The associated cranidia are all young, and differ from Walcott's ones in the greater convexity of the glabella. This difference may be attributed to the immature condition of the specimens.

The types are from a boulder in the Ville Guay conglomerate at Ville Guay (USNM locality 56a). The figured plesiotypes are from boulders 0–27 and 0–33, Island of Orléans.

Lectotype and paratypes.—USNM no. 18450. Plesiotypes: USNM no. 23525; Laval University nos. 489a–k.

Genus Olenoides Meek, 1877
Olenoides brevispinus Rasetti, n. sp.
Plate 52, figures 12–15

Known from several cranidia and associated pygidia.

Glabella weakly convex, the longitudinal convexity somewhat greater anteriorly. Glabella slightly tapered from the occipital furrow to the posterior glabellar furrows, somewhat expanded between this level and that of the ocular ridges, then markedly tapered, with narrowly rounded anterior angles. Three pairs of glabellar furrows, the posterior pair well impressed, bent backward at the inner end. Next pair short, anterior pair short and very shallow. Occipital furrow well impressed, especially at the sides. Occipital ring with a short, horizontal spine. Border in front of the glabella of moderate width and convexity; at the sides separated from the brim by a wide, shallow furrow. Fixed cheeks convex, their maximum width equaling one-half the glabellar width. Ocular ridges wide and faintly elevated. Palpebral lobes about one-third the glabellar length, moderately curved, set off by a well impressed palpebral furrow. Posterior limbs of average shape for the genus, with a wide, shallow marginal furrow.

Pygidium with a rather strongly tapered axis showing four segments and a terminal section. There is a node on the first segment. Pleural lobes with four pairs of broad furrows and as many distinct grooves. Pleura terminated into four pairs of strong spines whose length cannot be ascertained as they are broken off in the available specimens.

All the elevated portions of the cranidium and pygidium are covered with fine granules.

Length of largest cranidium (exclusive of occipital spine) 11 mm.

Of the described four-spined species of *Olenoides*, all those whose cranidium is known have a glabella of very different shape. There are a few species, particularly *O. pugio* (Walcott) and *O. maladensis* Resser, whose cranidia have not been described, and

it is difficult to establish a significant comparison with these.

Boulder M-25, Métis.

Holotype and paratypes.—Laval University nos. 476a–d.

OLENOIDES GRANULATUS Rasetti, n. sp.
Plate 51, figures 15–17

Known from several cranidia and associated pygidia.

Glabella moderately convex, parallel-sided from the occipital furrow to the level of the ocular ridges, then rather strongly tapered; anterior angles narrowly rounded. Posterior glabellar furrows very shallow, curved backward at their inner ends. Two other pairs indicated on the outer surface only by the absence of surface sculpture. Occipital furrow narrow but fairly deep at the sides, very shallow mesially. Characters of the occipital spine unknown. Border rather narrow, flat, somewhat upturned, set off from the brim at the sides by a shallow furrow. Ocular ridges wide and low. Fixed cheeks almost horizontal, with a maximum width about one-third the glabellar width. Palpebral lobes one-third the glabellar length. Posterior limbs only partly preserved.

Pygidium with a low, strongly tapered axis showing three segments and a terminal section. Each segment with a small node. Pleural lobes with four pairs of broad, shallow furrows and three pairs of shallow grooves. Marginal furrow wide and shallow but distinct. Four pairs of marginal spines, directed almost straight backward, rather strong, especially the first two pairs.

Almost the whole area of the two shields is densely covered with fine granules, larger on the elevated portions.

Length of largest cranidium 6 mm.; length of pygidium 4.4 mm., width 7 mm.

The cranidium differs considerably from those of the four-spined species of *Olenoides* for which this part of the shield is known, since they all have an expanding rather than a tapered glabella; perhaps the most similar are two Lower Cambrian species described by Resser, *O. nitidus* and *O. ornatus*. However, the associations of this species show that it is definitely Middle Cambrian.

Boulder B-13, Bic.

Holotype and paratypes.—Laval University nos. 477a–c.

OLENOIDES MÉTISENSIS Rasetti, n. sp.
Plate 51, figures 1–4

This is a large species known from numerous associated cranidia and pygidia.

Glabella strongly convex in both directions, greatly elevated above the rest of the cranidium, unfurrowed; longitudinal convexity greatest in the middle. Glabella almost straightsided, moderately expanded forward; anterior angles rather sharp, frontal outline uniformly curved. Occipital spine long, almost vertical. Border in front of the glabella extremely narrow; at the sides poorly differentiated from the brim. Fixed cheeks sloping downward, weakly convex; their maximum width somewhat less than half the glabellar width. Ocular ridges very faint. Palpebral lobes about one-fourth the glabellar length, flat, set off by a shallow palpebral furrow.

Pygidium with a moderately convex axis showing five segments and a terminal section. Axial furrows shallower mesially. Low nodes present on the first two segments. Pleural lobes with only three pairs of furrows and as many grooves; the third pair of grooves directed longitudinally and close to the axis for their entire course. Furrows and grooves broad, deeper distally where they end rather abruptly in the marginal furrow; the latter poorly defined. Border convex. Four pairs of long, cylindrical marginal spines. Anterior angles of pygidium sharp; first spine situated somewhat back of the angle, directed at about 45 degrees. Second spine slightly more oblique; third spine directed almost straight backward. Distance between third and second spine somewhat greater than between second and first. Spines of fourth pair smaller than the others and directed backward; distance between them about equal to distance between fourth and third spine and much smaller than the distance between the other pairs of spines.

Surface of glabella with faint concentric ridges, a type of ornamentation frequent in the closely related genus *Bonnia*. Surface of pygidium poorly preserved, apparently smooth.

Length of largest cranidium 30 mm., length of largest pygidium 30 mm., width 46 mm.

This species might be compared with *O. pugio* (Walcott), *O. curticei* Walcott and *O.*

maladensis Resser. It differs from all of them in the unusual distribution of the marginal pygidial spines.

Boulder M-19, Métis.

Holotype and paratypes.—Laval University nos. 478a–n.

OLENOIDES CONVEXUS Rasetti, n. sp.
Plate 51, figures 5–9

Known from several cranidia and associated pygidia.

Glabella highly convex in both directions, straight-sided, expanding toward the front, unfurrowed. Occipital furrow deep; occipital ring with a long, upright spine. Border in front of the glabella very narrow and poorly defined; at the sides separated from the brim by a shallow furrow. Dorsal furrows fairly deep, with well-marked anterior pits. Fixed cheeks sloping downward. Ocular ridges very faint; palpebral lobes of average size and position.

Pygidium with a moderately tapered axis showing four segments and a terminal section. Axial furrows of moderate depth. Pleural lobes with four pairs of furrows and three pairs of interpleural grooves, all about equally impressed, terminating in a poorly defined marginal furrow. The fourth furrow is parallel and very close to the axis, so that there is no space for a fourth pair of interpleural grooves. Four pairs of long, cylindrical marginal spines, each one starting at a point slightly in advance of the corresponding pleural furrow. The spines are directed somewhat upward. The distances between successive spines increase progressively, and the distance between the spines of the fourth pair is greater than the distance between the third and the fourth pair.

Surface of glabella characterized by a strong ornamentation consisting of granules arranged in concentric ridges. Fixed cheeks with fine granules. Prominent parts of pygidium granulated; there is just a suggestion of a node on each of the first two or three axial segments of the pygidium.

Length of largest cranidium 15 mm., length of largest pygidium 13 mm., width 22 mm.

This species differs from *O. métisensis* chiefly in the different arrangement of the pleural furrows and grooves and of the marginal spines on the pygidium. Of the other similar four-spined species, *O. curticei* has glabellar furrows; *O. maladensis* has shorter and differently distributed marginal pygidial spines. *O. pugio* seems to have a similar pygidium, but is only known from very fragmentary material, and its cranidium is unknown; hence a close comparison cannot be established.

Boulder G-6, Grosses Roches.

Holotype and paratypes.—Laval University nos. 479a–f.

OLENOIDES FOVEOLATUS Rasetti, n. sp.
Plate 51, figures 10–14

Known from numerous cranidia and associated pygidia.

Glabella weakly convex, expanding toward the front between the level of the posterior glabellar furrows and the ocular ridges, then rather sharply tapered, somewhat pointed in front. Three pairs of glabellar furrows well impressed, with a suggestion of a fourth pair. Posterior furrows deep, first directed straight inward, then turning sharply backward, then again inward; not meeting across the glabella. This shape of the posterior glabellar furrows is rather usual in the genus. Next pair shallower and shorter, somewhat curved backward. Anterior pair short and still shallower. Occipital furrow very shallow mesially; occipital spine rather strong. Border in front of the glabella narrow, flat, upturned; with a somewhat pointed outline as the glabella itself. Border rather well defined from the brim at the sides by the change in slope. Fixed cheeks weakly convex, sloping downward; their maximum width somewhat more than one-third the glabellar width. Ocular ridges rather strong; palpebral lobes short for the genus, curved, slightly elevated, set off by a wide, shallow furrow. Posterior limbs rather long for the genus.

Pygidium with a low, moderately tapered axis composed of four segments and a terminal section. Axial furrows shallower and wider mesially. On the anterior half of each segment there is a somewhat indistinct pair of elevations. No nodes or spines on the axis. Pleural lobes with five pairs of pleural furrows and four pairs of narrower but distinct interpleural grooves. Furrows and grooves extend somewhat beyond the wide, shallow marginal furrow. Five pairs of mar-

ginal spines of moderate length, equidistant from each other and each opposite the corresponding pleural furrow.

Surface of cranidium, thoracic segments and pygidium densely covered with very fine granules.

Length of largest cranidium 25 mm.; length of largest pygidium 27 mm., width 48 mm.

This species can be readily distinguished from most of the described five-spined species by the low convexity of the shields and the well-impressed glabellar furrows. One of the most similar forms seems to be *O. serratus* (Rominger), which has glabellar furrows of the same type, but possesses axial nodes on the pygidial axis. A species from Newfoundland described by Howell as *Kootenia longispina*, judging by the published illustrations, seems to the writer fully typical of *Olenoides* and close to the present species as far as the cranidial features are concerned. The pygidium, however, has much longer spines and other distinctive features.

Boulder L-13, Ville Guay.

Holotype and paratypes.—Laval University nos. 480a–j.

OLENOIDES cf. O. SERRATUS (Rominger)
Plate 52, figures 9–11

Ogygia serrata ROMINGER, 1887, Acad. Nat. Sci. Philadelphia Proc., p. 13, pl. 1, fig. 2.
Neolenus serratus (Rominger). MATTHEW, 1899, Roy. Soc. Canada Trans., vol. 5, sect. 4, p. 53.
Olenoides serratus (Rominger). KOBAYASHI, 1935, Jour. Fac. Sci. Imp. Univ. Tokyo, sect. 2, vol. 4, pt. 2, p. 154.

Several cranidia and associated pygidia recovered from one boulder are assigned to this species with some uncertainty, because of the difficulty in establishing a close comparison between undistorted specimens preserved in limestone and the complete but flattened shields of *O. serratus* from the typical locality, the *Ogygopsis* shale on Mt. Stephen, British Columbia.

No complete cranidium is available, but the fragments show enough of the glabella, fixed cheeks and border to indicate close similarity of all these parts to those of *O. serratus*.

Well-preserved pygidia are available. The axis shows four segments, each bearing a short spine or node, and a terminal section. The pleural lobes show four well-impressed furrows, and a fifth rather indistinct, plus four pairs of interpleural grooves. The five marginal spines have the size and position observed in *O. serratus*. The surface of the pygidia is better preserved than that of the cranidia and shows a very fine granulation.

Length of largest cranidium 18 mm.; length of largest pygidium 19 mm., width 34 mm.

Boulder L-9, Ville Guay.

Figured specimens.—Laval University nos. 481a–h.

MANUSCRIPT RECEIVED JUNE 23, 1947.

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LOWER CAMBRIAN PLEOSPONGIA FROM THE PURCELL RANGE OF BRITISH COLUMBIA, CANADA

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ABSTRACT—A collection of pleosponges from the Lower Cambrian Donald formation in the Dogtooth Mountains, Purcell Range, of British Columbia is described and illustrated. The collection contains representatives of sixteen species, ten of which are new. The Pleosponges occur in association with *Olenellus*, *Rustella*, and other typical Lower Cambrian fossils. The fauna indicates a closer relationship to the Asiatic and Australian forms than to the pleosponges of the Silver Peak-Waucoba Canyon region of California and Nevada.

INTRODUCTION

IN THE Cordilleran Province of North America pleosponges (Archaeocyatha) occur in the Lower Cambrian at five widely separated localities. They have been reported from the vicinity of Caborca, Sonora, Mexico; the Silver Peak-Waucoba Springs area of Nevada and California; the Colville region of Washington; the Dogtooth Mountains of Purcell Range of southern British Columbia, and the Aiken Lake area of central British Columbia. The Mexican and the California-Nevada localities have so far provided the greatest number of specimens. (Okulitch 1943). The Colville region (Resser, 1934) yielded some very doubtful fragments. The Aiken Lake fossils were described in 1947 issue of the Transactions of the Royal Society of Canada. The present paper deals with specimens collected in 1926 by Dr. Evans of the Geological Survey of Canada and by Okulitch in the summer of 1946.

There is no close relationship between the species found in the northern and southern portions of the Cordilleran province. This strengthens the supposition that the northern and southern embayments of the Lower Cambrian seas within the Cordilleran geosyncline had no direct connection with each other. This connection was established only much later in the Middle Cambrian. On the other hand very pronounced similarity exists between the British Columbian and Siberian and Australian faunas.

This work was made possible by a grant from the Penrose bequest by the Geological Society of America. In a sense it is a continuation of my former work on North American Pleospongia begun in 1935. I am greatly indebted to Dr. Cooper of the U. S. National Museum and Dr. Bell of the Geological Survey of Canada for making available specimens collected by Dr. Evans from the Dogtooth Mountains. The work was greatly facilitated by Dr. Evans, whose extraordinarily good work in mapping the area in 1926, and personal suggestions about the best fossil localities were of great help in finding additional specimens. The Forestry rangers in the Golden area, Mr. Melvyn Mikkelson of Golden, B. C., and Mr. T. Weir of the University of British Columbia helped in making the collection of fossils, in this most difficult area, an easier job than it otherwise would have been.

LOCATION AND STRATIGRAPHY

The Dogtooth Mountains are the easternmost part of the Purcell Range, forming the western wall of the Rocky Mountain trench from the mouth of Spillimacheen River in the south to the junction of Beaver River and the Columbia River in the north. The mountains are composed of tilted, folded and strongly faulted rocks of Precambrian and later age. Evans (1932) gives the generalized geologic section shown in Table 1.

The pleosponges are found only in the Donald formation, in association with *Kutorgina*, *Micromitra*, *Bonnia*, *Olenellus*, *Rustella*, *Hyolithes*, *Salterella* and *Dorypyge*.

The maximum thickness of the Donald strata is about 1,500 feet. Evans (1932)

gives the following description of the formation.

Top of section	Feet
7. Limy slates with dark dense limestone nodules and bands	800
6. Alternating impure limestone, sandstone and slates	400–800
5. Cream-coloured, coarsely crystalline limestone, reddish at base	30–40
4. Massive hard sandstone	0–35
3. Green slates, limy or sandy in different localities	120
2. Sandy limestone and slates	150
1. Six-inch, hard sandstone beds alternating with slates	25

Pleosponges have been found in beds 2, 5, and 7 of the formation. Bed 5 has the largest pleospongian fauna and makes a natural horizon marker in the area.

Rugged topography, thick vegetation on the lower slopes, and lack of trails makes the collection of fossils in the region a difficult undertaking. The best outcrops of Donald strata can be reached by working up the high rims of either Holt Creek canyon or Canyon Creek to elevations of from 5,500 to 7,500 feet above sea level. It was found most advantageous for a small party to make Golden, B. C. the starting point and to cross the Columbia River by the only existing bridge at Nicholson. Abandoned logging trails can be used to take one part of the way up the mountains. Most of the fossils were collected in outcrops and loose boulders on the south side of Holt Creek, west of its juncture with Gorman Creek. The ruggedness of the terrain made it necessary to back-pack all supplies into the collecting area. Undoubtedly a larger collection of fossils could have been made by a larger party working with pack horses and establishing a semi-permanent camp in the headwaters of Holt Creek. Lack of sufficient time, money, and trained assistants prevented my doing this.

TABLE 1. GENERALIZED GEOLOGIC SECTION IN THE DOGTOOTH MOUNTAINS

Eras	Epochs	Formations
Paleozoic	Middle Cambrian	Canyon Creek
	Lower Cambrian	Donald St. Piran Lake Louise Fort Mountain
Late Precambrian	Windermere	Horsethief Creek Toby
	Purcell	Mount Nelson

LIST OF SPECIES

CLASS PLEOSPONGIA

SUBCLASS ARCHAEOCYATHA

Order AJACICYATHINA

Ajacicyathus nevadensis (Okulitch)
Ajacicyathus purcellensis n. sp.
Ajacicyathus undulatus n. sp.
Coscinocyathus dentocanis Okulitch
Coscinocyathus rhyacoensis n. sp.
Coscinocyathus sp.

Order METACYATHINA

Archaeocyathus atlanticus Billings
Archaeocyathus taeniatus n. sp.
Copleicyathus (?) laminosus n. sp.
Cambrocyathus donaldi n. sp.
Cambrocyathus columbianus Okulitch
Cambrocyathus septimus n. sp.
Cambrocyathus sp.
Archaeosycon evansi n. sp.
Eucyathus obliquus n. sp.
Pycnoidocoscinus rectiporus n. sp.

DESCRIPTION OF SPECIES

Order AJACICYATHINA

AJACICYATHUS NEVADENSIS (Okulitch)

Plate 53, figure 1

This species is fairly common in the Lower Cambrian of Silver Peak, Nevada and Inyo County, California. It was fully described by Okulitch in 1943. In the Dogtooth area only one specimen was found. It occurs in bed 5 of the Donald formation. The Dogtooth specimen agrees in all particulars with the holotype of *Ajacicyathus nevadensis*.

AJACICYATHUS PURCELLENSIS
Okulitch n. sp.
Plate 53, figures 2, 3

The species is based on specimen USNM 108118, previously illustrated, but not described in 1943, and specimen no. 8 collected by Okulitch in 1946.

General shape.—Both specimens show a natural cross-section of elliptical shape.

Larger diameter: about 30 mm.
Short diameter: about 21 mm.
Width of intervallum: 4 mm. to 6 mm.
Average diameter: 25 mm.
Average width of intervallum: 5 mm.
Average width of central cavity: 12 mm.
Number of parieties: 80 at width of 25 mm.
Intervallum coefficient: 5:12 or 0.4
Parietal coefficient: 80:25 = 3.2

Outer wall not visible in either specimen. Intervallum of medium width, crossed by moderate number of parieties. Parieties straight, radial, very thin, with no additional skeletal tissue of any kind. The parieties are perforated by numerous exceedingly fine pores.

Inner wall thin, simple, without additional skeletal structures, apparently perforated by two to three small pores per intersept.

Affinities.—The species is nearest in general appearance, thin straight parieties, and fine pores to *Ajacicyathus profundomimus* Okulitch, a fairly common species in the lower Cambrian of the Appalachian province. It differs from it in having a considerably higher intervallum coefficient and lower parietal coefficient. Somewhat similar form, but with a different parietal and intervallum coefficients, was described by Vologdin under the name *Archaeocyathus salebrosus* from the Cambrian of Siberia.

Cotypes.—No. 8, V. J. Okulitch collection, University of B. C.; USNM 108118 now with the collections of the Geological Survey of Canada, Ottawa; and Geological Survey Canada, 9514.

Horizon and locality.—Bed 5, Donald formation, Lower Cambrian. Dogtooth Mountains, Purcell Range, British Columbia. The species is common in the Lower Cambrian of the northern Cordilleran province.

AJACICYATHUS UNDULATUS
Okulitch n. sp.
Plate 53, figure 4

The single known specimen of this species was found in the same piece of limestone containing *Coscinocyathus dentocanis* Okulitch and is marked Evans 7 K 11–2. and USNM 108101–2. The specimen consists of a fragment of a relatively large ajacicyathid with a very narrow intervallum. The general shape of the species must have been bowl-like with irregularly wavy walls. Since only a fragment is known it is impossible to determine accurately either the parietal or the intervallum coefficients. The estimated coefficients are: intervallum coefficient—1.5:60 or 0.025; parietal coefficient—752:60 or 12.5.

The total diameter of the cup could not be less than 60 mm. and probably was more. The intervallum is 1.5 mm. wide, with straight simple parieties spaced three to four per millimeter. The intersepts are, therefore, quite elongated, being on the average 0.3 mm. ×1.5 mm. in size.

The new species undoubtedly finds its nearest relatives among the group of Ajacicyathidae with narrow intervallum and flexible walls described by Vologdin (1931) under the names *Archaeocyathus* (*Ajacicyathus*) *clarus* and *Archaeocyathus* (*Ajacicyathus*) *arteintervallum* from the Lower Cambrian of Lower Ters River in Siberia. Our species differs from them in having much narrower parietal intersepts and generally larger size.

Holotype.—Geol. Survey of Canada, 9515, Evans Collection.

Horizon and locality.—Bed 5, Donald formation, Lower Cambrian. Dogtooth Range, B. C.

COSCINOCYATHUS DENTOCANIS Okulitch
Plate 53, figure 5

OKULITCH, 1943, Geol. Soc. America Special Paper, no. 48, p. 67, plate 4.

The specimen is a naturally weathered out longitudinal section in light-grey limestone.

General Shape.—Tubular, with very slight taper. Reconstructed diameter must have been about 22 mm., and height about 60 or 70 mm., of which 50 mm. is visible. Width of intervallum is 5 mm. where diameter of

central cavity is 12 mm., giving an intervallum coefficient of 5:12 or 0.4.

Outer wall probably thin and simple. Intervallum is crossed by radial vertical parieties and tabulae slightly convex upward. Resultant rectangular cells or loculi are about twice as high as wide; 14 parieties occur in space of 1 cm., giving a parietal coefficient of about 4.5; tabulae are about 1.5 mm. apart.

Inner wall is apparently smooth and simple, without any structures projecting into central cavity.

Affinities.—No close affinities to any other American species are indicated. The specimen is quite unique, and its imperfect preservation prevents more detailed knowledge of the species. It apparently belongs to the group of Coscinocyathidae with oblong loculi like *C. australis* Taylor.

Holotype.—9516, Geological Survey of Canada, Ottawa, Canada.

Horizon and locality.—Donald formation, Lower Cambrian. Canyon Creek, Dogtooth Mountains, B.C. Collected by Dr. C. Evans.

COSCINOCYATHUS RHYACOENSIS Okulitch n. sp.
Plate 53, figures 7, 8

General shape.—A fragment showing portion of the intervallum of a truncated conical specimen broken obliquely across.

Average diameter: 12 mm.

Total length: 23 mm.

Width of intervallum: 3 mm.

Diameter of central cavity: about 6 mm.

Probable intervallum coefficient: 3:6, or 0.5.

Outer wall thin, with gentle transverse annulations. Wall pierced by fairly large canal-pores. Intervallum crossed by numerous thin straight parieties spaced about 0.7 mm. apart and strongly up-arched tabulae spaced about 0.7 mm. apart,—resulting in quadrate loculi. Both parieties and tabulae are perforated by pores. The pores of the tabulae are larger and more numerous than those of the parieties. In addition the loculi are crossed by some very thin and irregular dissepiments.

Inner wall thick, or thickened, perforated by fairly coarse round pores arranged in quincunx. One row of pores occurs per intersept. The spacing of pores suggests that one pore opens into each loculum.

Central cavity not directly visible, but judging from the structure of the rest of the specimen, it should be cylindrical or truncated conical and about 6 mm. in diameter.

Affinities.—A *Coscinocyathus* with quadrate loculi. Easily differentiated from *Coscinocyathus dentocanis* because of closer spacing of tabulae. The species appears to be almost identical to *Coscinocyathus quadratus* Bedford from Australia (Bedford, 1934 p. 3) from which it differs only in having one row of pores per intersept instead of two. It might be that this difference is of insufficient importance to base a new species on, in which case, *Coscinocyathus rhyacoensis* should be called *C. quadratus*. Specific name refers to the finding of the specimen in a creek. (Rhyaco = Creek).

Holotype.—No. 7, V. J. Okulitch collection, University of B. C.

Horizon and locality.—Donald formation, Lower Cambrian. In a boulder of Donald limestone in Holt Creek, Dogtooth Mountains, B. C.

COSCINOCYATHUS sp.
Plate 53 figure 6

This specimen ws collected by Dr. Evans and is marked 7 K 11. It is an acutely conical fragment exposing a pleosponge in a natural longitudinal section. The specimen is entirely recrystallized and no details of its structure, except a few upward arching tabulae, are visible. The intervallum coefficient is 4:6 or 0.6; the tabulae are spaced from 1½ mm. to 2 mm. apart. The total length of the specimen is 40 mm. and the maximum diameter is 14 mm. An exposed portion of the inner wall indistinctly shows numerous, crowded, very fine pores. The outer wall is worn smooth and does not show the pores. In one portion of the specimen are faintly visible thin straight parieties spaced about one-third of a millimeter apart. The poor preservation of the specimen does not permit its specific determination beyond the fact that it is a *Coscinocyathus* with elongated rectangular loculi.

Figured specimen.—9517, Geological Survey of Canada collection.

Horizon and locality.—Donald formation, Lower Cambrian. Dogtooth Range, B. C.

Order METACYATHINA

ARCHAEOCYATHUS ATLANTICUS Billings

Plate 54, figures 1, 2

Archaeocyathus atlanticus Billings, 1861
Spirocyathus atlanticus Hinde, 1889
Archaeocyathus atlanticus Okulitch, 1937, 1940, 1943

This species has practically world-wide distribution. In some cases practically identical forms have been given new specific names. In the collection it is represented by two very small specimens 5 mm. and 7 mm. in diameter respectively. These have been designated numbers 3 and 1c. Both are apparently young *A. atlanticus*, although they differ from the holotype by having a slightly wider central cavity and the intervallum is filled by more delicate taeniae. It is not regarded that these differences are of sufficient importance to justify the erection of a new species.

	Specimen 3	Specimen 1c
Total diameter:	5 mm.	7 mm.
Diameter of central cavity:	1.5–2 mm.	2 mm.–3 mm.

Figured specimens.—V. J. Okulitch collection, University of B. C.
Horizon and locality.—Bed 5, Donald formation, Lower Cambrian. Holt Creek, Dogtooth Mountains, B. C.

ARCHAEOCYATHUS TAENIATUS

Okulitch n. sp.

Plate 54, figure 8

The species is based on a single poorly preserved specimen from which the transverse thin section has been prepared. Sufficient detail is visible in the thin section to recognize the pleosponge as an *Archaeocyathus* with a distinctive pattern of taeniae in the intervallum.

General shape.—As exposed in the thin section the organism must have been a slightly flattened cone or cup. The outer and inner walls are connected by numerous curving, branching, and anastomosing taeniae. The taeniae are much more delicate and thin than in any other *Archaeocyathus* known to me and resemble intervallum tissue of a Protopharetra. However the width of its central cavity, the slight tendency to radial arrangement of taeniae, and the definite shape of the cup leave no doubt that the specimen is an *Archaeocyathus*.

Total diameter: 12 mm. ×15 mm.
Diameter of central cavity: 4 mm.
Width of intervallum: 4 mm.
Intervallum coefficient: 4:4 or 1.0
Number of parieties: about 40
Parietal coefficient: 3.3

Outer wall thin, apparently irregularly porous, deflected inward between parieties. The specimen, therefore, must have a ribbed appearance. Taeniae thin, irregularly branching and curving near outer wall, but becoming more distinctly radial near inner wall, pierced by large pores.

Inner wall thicker than outer wall, with some tendency to bulge into central cavity. A few small plates or rods project into central cavity, but the wall is essentially smooth and simple. Pores are of the canal-pore type, both horizontal and inclined.

Central cavity free of all skeletal tissue.

EXPLANATION OF PLATE 53

FIGS. *1*—*Ajacicyathus nevadensis* (Okulitch), ×6. Transverse thin section of a young individual. (p. 341)

2, 3—*Ajacicyathus purcellensis* Okulitch, n. sp. *2*, Cotype, ×1.7. Geol. Survey, Canada. Naturally weathered out transverse section. *3*, Cotype, ×1.4. Univ. of British Columbia. (p. 342)

4—*Ajacicyathus undulatus* Okulitch, n. sp., ×4. Holotype, Geol. Survey, Canada. Naturally weathered out fragment of a large individual. (p. 342)

5—*Coscinocyathus dentocanis* Okulitch, ×1.1. Holotype, Geol. Survey, Canada. Oblique longitudinal section, showing central cavity, parieties, and tabulae. (p. 342)

6—*Coscinocyathus* sp., ×1.1. Weathered fragment showing central cavity, intervallum, and portion of outer wall. (p. 343)

7, 8—*Coscinocyathus rhyacoensis* Okulitch, n. sp. *7*, Holotype, ×2. No. 7, Univ. of British Columbia. Naturally weathered out longitudinal section. *8*, Holotype, ×4. Longitudinal thin section showing tabulae and parieties. (p. 343)

9—*Cambrocyathus* (*?*) *septimus* Okulitch, n. sp., ×3. Holotype, No. 10, Univ. of British Columbia. Transverse thin section showing inner and outer walls and parieties. (p. 346)

Affinities.—Resembles *Archaeocyathus constrictus* (Raymond) in its intervallum coefficient and diameter, but differs in the more delicately constructed taeniae.
Holotype.—No. 5, V. J. Okulitch collection, University of B. C.
Horizon and locality.—Bed 5, Donald formation, Lower Cambrian. South side of Holt Creek, Dogtooth Mountains, B. C.

? Copleicyathus laminosus Okulitch, n. sp.
Plate 55, figure 6

The species is represented in the collection by a single fragment. A transverse section of the specimen shows very clearly the details of its structure. No distinct central cavity is present, as this space is occupied by complex skeletal tissue, a continuation of the inner wall. This skeletal tissue consists of a mass of thickened anastomosing laminae and curved dissepiments, perforated by numerous vertical, inclined, and horizontal pores and canals. The intervallum is occupied by irregular branching and curving parieties, dissepiments, and synapticulae.

The specimen measures 9 mm. by 19 mm. The central cavity is about 8 mm. in diameter, and the intervallum is about 5 mm. wide. This gives an intervallum coefficient of 5:8, or 0.6. The parieties are spaced about 1 mm. apart. Some of the laminae occupying the central cavity appear to be continuations of the parieties. Near the outer wall the parieties, in many cases, bifurcate forming irregular loops.
Affinities.—The nearest described genus with similar characteristics is *Copleicyathus* Bedford (1937) from the Lower Cambrian of Australia. Our species differs from *Copleicyathus confertus* Bedford in having a less tightly filled central cavity, consisting essentially of irregular plates, rather than a "felted" mass of anastomosing rods. There is no other American genus even remotely resembling the new species.
Holotype.—No. 14, V. J. Okulitch collection, University of British Columbia.
Horizon and locality.—Lower Cambrian, Donald formation. Holt Creek, Dogtooth Mountains, B. C.

Cambrocyathus donaldi Okulitch n. sp.
Plate 54, figures 3–5

The description of this species is based on two specimens collected in the Donald formation on Holt Creek, Dogtooth Mountains, B. C. They are therefore designated as cotypes. *Cambrocyathus donaldi* is a moderately large pleosponge, cylindroconical in shape with the complicated parieties of Cambrocyathidae.
Total diameter: 20 mm.
Diameter of central cavity: 7 mm.–8 mm.
Width of intervallum: 6mm. to 7 mm.

Outer wall relatively thick with at least two rows of pores per intersept. Intervallum

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Explanation of Plate 54

Figs. *1, 2*—*Archaeocyathus atlanticus* Billings. *1*, No. 1c, University of British Columbia, ×6. Transverse thin section showing central cavity and intervallum. *2*, No. 2, University of British Columbia, ×2, Naturally weathered out transverse section. (p. 344)
3–5—*Cambrocyathus donaldi* Okulitch, n. sp. *3*, Cotype, ×2. No. 4, University of British Columbia. Weathered out fragment showing thin outer and inner walls and thickened parieties. *4*, Cotype, ×2. No. 2, University of British Columbia. Appearance of specimen before a thin section illustrated on fig. *5* was prepared from it. *5*, Cotype, ×3.7. No. 2, University of British Columbia, Transverse thin section showing the walls and parieties with synapticulae. (p. 345)
6—*Cambrocyathus columbianus* Okulitch, ×1.6. Paratype, Geol. Survey, Canada. Naturally weathered transverse section, showing details of walls and parieties with synapticulae. (p. 346)
7—*Cambrocyathus* sp., ×4. Transverse thin section of a fragment showing the typical parieties with synapticulae and dissepiments. (p. 346)
8—*Archaeocyathus taeniatus* Okulitch, n. sp., ×4. Holotype, No. 5, University of British Columbia. Transverse thin section, showing thin curved taeniae in the intervallum. Outer wall is extremely thin and porous. (p. 344)
9—*Archaeosycon evansi* Okulitch, n. sp., ×2. Holotype, No. 1a, University of British Columbia. Naturally weathered transverse section. Thin section of the same specimen is shown on Pl. 55, fig. *1*. (p. 347)

relatively wide, one third of total diameter. Crossed by numerous thin radial parieties. The parieties are 76 in number for a total diameter of the cup of 20 mm. giving a parietal coefficient of about 4. The parieties are perforated by numerous small pores, are joined by thick synapticulae, and some of them bifurcate towards the outer wall. The intervallum coefficient is 7:7 or 1.0.

Inner wall thin, somewhat irregular, and perforated by numerous pores. Central cavity elliptical to circular, free of all skeletal tissue.

Affinities.—A *Cambrocyathus* with no close affinities to any other American species. It has points of resemblance to the Siberian genus *Sibiricyathus*, but differs from all known species of it or *Cambrocyathus* in the different parietal and intervallum coefficients and the tendency of the parieties to bifurcate.

Cotypes.—V. J. Okulitch collection, Nos. 2 and 4, University of British Columbia.

Horizon and locality.—Bed 5, Donald formation, Lower Cambrian. Holt Creek, Dogtooth Mountains, British Columbia.

CAMBROCYATHUS COLUMBIANUS Okulitch
Plate 54, figure 6

Okulitch, 1943, Geological Society of America, Special Paper, Number 48, p. 78, Plates 12 and 13.

Among specimens collected by Evans in the Dogtooth Range, British Columbia two belong to this species. The specimens are imbedded in brown or pink limestone and are almost completely recrystallized to pink calcite.

General shape.—Gently expanding conical cup. Average diameter of upper surface is 45 mm. at a height of about 50–60 mm. Exact height could not be measured as tip of cup is broken off. Outer surface is gently, and not very distinctly, transversely annulated. Width of intervallum is about 10 mm., thus giving an intervallum coefficient of 10 mm.:25 mm. to 10 mm.:30 mm.

Outer wall almost completely eroded in both specimens, but apparently simple, thin, and perforated by numerous small pores. Intervallum fairly wide, wider than in *C. profundus* and narrower than in *C. amourensis*, in relation to total diameter of the specimens, thus placing *C. columbianus* in an intermediate position to these two common species. Parieties are simple, radial, interconnected with very few synapticulae; 10 parieties occur in space of 10 mm., giving a total of 157. Parietal coefficient is, therefore, about 3.0, which is again intermediate between that of *C. amourensis* and *C. profundus*.

Parieties are perforated by numerous small pores, about 12 occurring on a random cross section. Synapticulae are somewhat more crowded toward inner wall, but in general very few for the genus.

Inner wall is very thin, considerably thinner than either parieties or outer wall. It appears to be perfectly simple. Nothing is known about its pores.

Affinities.—The species is regarded as intermediate between *C. profundus* and *C. amourensis*. It differs from both in its intervallum and parietal coefficients, relative scarcity of synapticulae, and stoutness of its parieties.

Cotypes.—9518, 9519, Geological Survey of Canada.

Horizon and locality.—Donald formation, Lower Cambrian. Canyon Creek, near Golden B. C., Dogtooth Range, British Columbia. Collector: C. Evans.

CAMBROCYATHUS sp.
Plate 54, figure 7

The specimen is a fragment showing a portion of the intervallum of a *Cambrocyathus*. The spacing of the parieties is different from other species of *Cambrocyathus* described from the area. The absence of outer and inner wall makes it impossible to determine the species to which the fragment belongs, although it appears to be fairly close to such Cambrocyathidae as *Cambrocyathus amourensis* Okulitch.

Horizon and locality.—Donald formation, Lower Cambrian. Holt Creek, Dogtooth Range, B. C.

? CAMBROCYATHUS SEPTIMUS Okulitch n. sp.
Plate 53, figure 9

General shape.—Long tapering conical. Diameter at top is 7 mm., length is 30 mm. The specimen is imbedded in partly decomposed "blue" limestone filled with iron oxide. Most details of structure are obliterated.

Outer wall thin, with numerous fine pores. Intervallum 1.5 mm. to 2.0 mm. wide crossed by widely spaced perforated parieties. Synapticulae are indistinctly indicated. Intervallum coefficient is 2:3, or 0.66; parietal coefficient is 26:7, or about 4.0.

Affinities.—Preservation is so poor that some doubt exists whether the specimen is a *Cambrocyathus*. If it is, it resembles most, by its intervallum and parietal coefficients, *Cambrocyathus ceratodictyoides* (Raymond). The main significance of the specimen is that it occurs higher in the Donald formation than any other pleosponges.

Holotype.—No. 10, V. J. Okulitch collection, University of British Columbia.

Horizon and locality.—Bed 6 or 7 of Donald formation, (most other pleosponges were collected from number 5). South side of Holt Creek, at elevation 7,000 feet above sea level.

ARCHAEOSYCON EVANSI Okulitch n. sp.
Plate 54, figure 9,
Plate 55, figure 1

The species is based on a single specimen from which a transverse thin-section was prepared. The specimen was imbedded in the reddish limestone (bed number 5) of the Donald formation. It is cylindrical to conical in shape with lower portion of the central cavity filled with vesicular tissue.

Total diameter: 11 mm.
Diameter of central cavity: 3 mm.
Width of intervallum: 4 mm.
Number of parieties: about 40.

Outer wall minutely crenulated longitudinally, about two to four crenulations spaced within an intersept. The outer wall is thicker than the inner wall. The wall is perforated by small pores spaced far apart. The pattern of pores is not known. Intervallum wide, slightly narrower than the intervallum of *Cambrocyathus amourensis*. Crossed by parieties and tabulae. The parieties are thick, distinctly radial, pierced by few (2–3) pores on random section. Pores have about the same diameter as the parieties are thick. Intervallum coefficient is 4:3 or 1.3; parietal coefficient is 40:11 or 3.6. Tabulae are irregularly porous, pores circular, mostly small, with a few larger pores near inner wall. Tabulae are strongly deflected downwards near outer wall. Tabulae are interconnected by irregular vertical elements (plates and rods); some of these resemble spicules in cross-section.

Inner wall indistinct, passes into skeletal elements filling central cavity. Thin irregular outgrowths project into central cavity. Central cavity narrow, filled with vesicular tissue consisting mostly of short vertical plates.

Affinities.—The species is undoubtedly a member of the Metacoscinidae, resembling such genera as *Archaeosycon*, *Metacoscinus*, and *Eucyathus*. It is placed with *Archaeosycon* because of the presence of vertical elements uniting the arched tabulae. It differs from other known species of *Archaeosycon* in its parietal and intervallum coefficients, and the platy skeletal tissue filling its central cavity.

Holotype.—No. 1a, V. J. Okulitch collection, University of British Columbia.

Horizon and locality.—Bed 5, Donald formation, Lower Cambrian. Holt Creek, Dogtooth Mountains, British Columbia. Specific name in honor of Dr. C. Evans.

EUCYATHUS OBLIQUUS Okulitch n. sp.
Plate 55, figures 4, 5

General shape.—Tubular to cylindro-conical. Details of inner structure of the species were obtained from two oblique thin sections. The specimen itself had to be destroyed in the process of preparing the thin sections.

Diameter: 13 mm.
Diameter of central cavity: 4.6 mm.
Width of intervallum: 4.2 mm.
Intervallum coefficient: 4.2:4.6 or 0.9
Parietal coefficient: about 40:13 or 3.0

Outer wall thin, regular; pore pattern unknown; gently transversely annulated, resembling outer wall annulations of *Archaeocyathus atlanticus*. The width of the intervallum is approximately equal to width of central cavity. Intervallum is crossed by porous parieties, tabulae, and synapticulae. Parieties are of *Cambrocyathus* type, i.e. the parieties are supplied with synapticulae. Vesicular tissue is present. The tabulae are oblique, dipping downward from inner wall to outer wall. The tabulae in places are irregular and resemble dissepiments, or change into an irregular vesicular mass. In an oblique section the tabulae and parieties form diamond-shaped loculi.

Inner wall is a coarse net with round pores arranged in quincunx. The wall is fairly thick, so the pores form short canals piercing it. Minute indistinct rods and hooks project into the central cavity. Central cavity is free from skeletal tissue in its upper portion. Condition of the lower part of the cup is not known.

Affinities.—The specimen undoubtedly belongs to the family Metacoscinidae Bedford. It is very close to the Siberian species *Eucyathus billingsi* Vologdin. The new species differs from it in the intervallum coefficient and the clearly porous, net-like, inner wall. It differs from the Australian genera *Metacoscinus* Bedford and *Paracoscinus* Bedford by having taeniae and vesicular tissue, which are lacking in the Australian Metacoscinidae.

Tentatively I place the specimen as a new species of *Eucyathus*. When additional material become available it might become necessary to erect a separate genus for this very unusual form.

Holotype.—No. 13, V. J. Okulitch collection, University of British Columbia.

Horizon and locality.—Beds 2 and 5, Donald formation, Lower Cambrian. Holt Creek, Dogtooth Mountains, British Columbia.

PYCNOIDOCOSCINUS RECTIPORUS
Okulitch n. sp.
Plate 55, figures 2, 3

The specimen is a naturally weathered out fragment exposing the interior in a longitudinal section grazing the inner wall. The fragment is slightly curved indicating that the pleosponge was horn-shaped.

Average diameter: 12 mm.
Length: 30 mm.
Central cavity: 4 mm. in diameter.

General shape.—Horn-shaped with marked transverse annulations, as in *Cambrocyathus profundus* (Billings) or *Pycnoidocoscinus pycnoideum* Bedford.

Outer wall relatively thick, no details of structure visible. Intervallum crossed by numerous closely spaced radial parieties and slightly up-arched tabulae. The tabulae are spaced closer than the parieties, giving horizontally elongated loculi. This is different from *Coscinocyathus dentocanis* Okulitch, whose loculi are higher than wide, or *Pycnoidocoscinus pycnoideum* Bedford (1936) whose tabulae are strongly arched and spaced farther apart.

Inner wall is similar to the inner wall of *Pycnoidocoscinus pycnoideum*. It consists of a regular mesh made of horizontal and vertical elements resulting in rectangular horizontally elongated pores. This is the most characteristic feature of the species. The central cavity is narrow—about 4 mm. in diameter. This gives an intervallum coefficient of about 4:4, or 1.0. The intervallum coefficient is very different from that of *Pycnoidocoscinus pycnoideum*, whose intervallum is relatively narrow.

The base of the specimen is lacking, so it is impossible to relate the species with certainty to either the Coscinocyathidae or Metacoscinidae, but the general appearance, and the similarity of details of inner wall to that of *Pycnoidocoscinus* make it highly probable that the new species belongs to the genus *Pycnoidocoscinus* and not to *Coscino-*

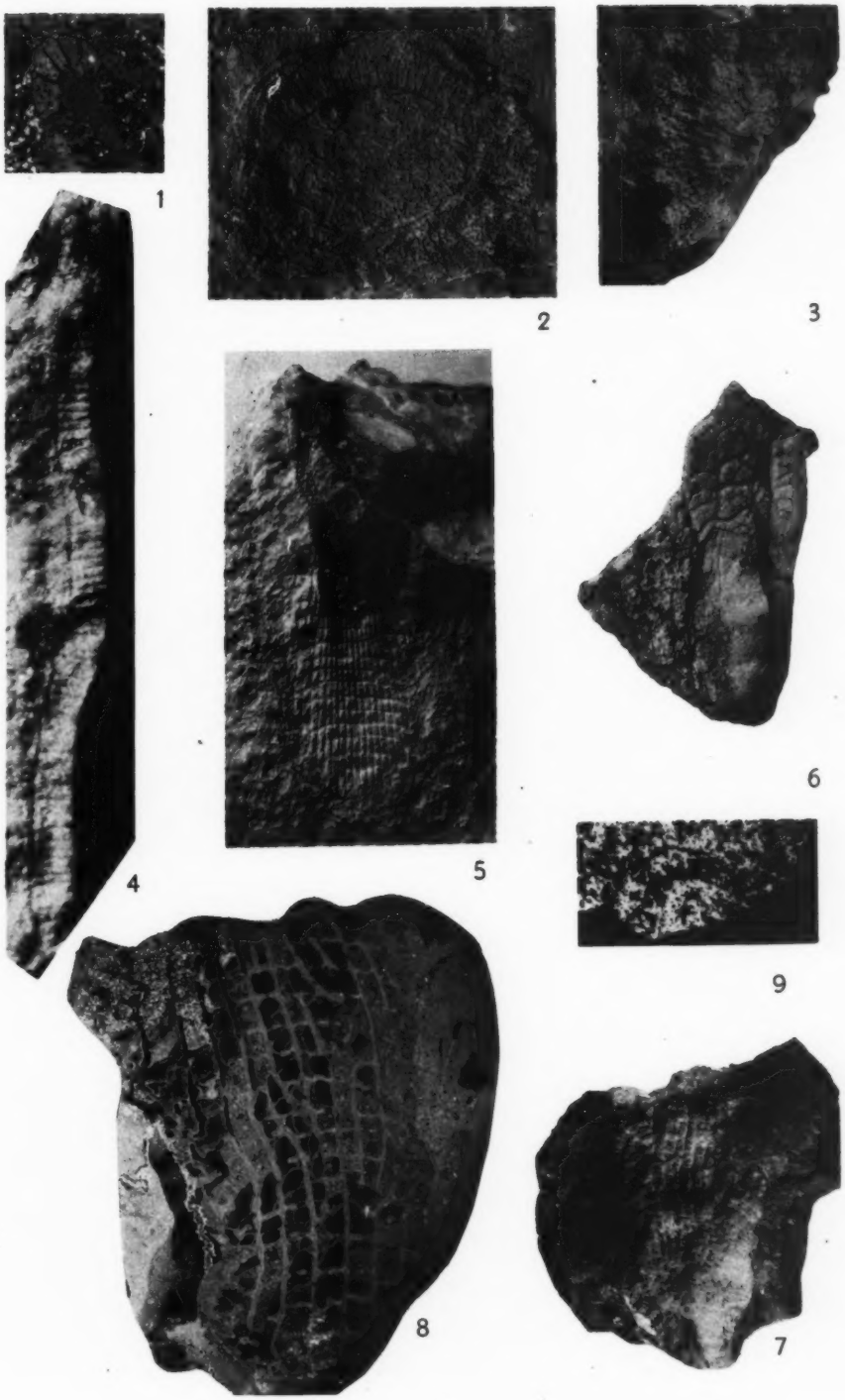
EXPLANATION OF PLATE 55

FIGS. *1*—*Archaeosycon evansi* Okulitch, n. sp., ×6.6. Holotype, No. 1a, University of British Columbia. Transverse thin section, showing parieties, taeniae, vertical plates and rods, and portions of perforate tabulae. (p. 347)

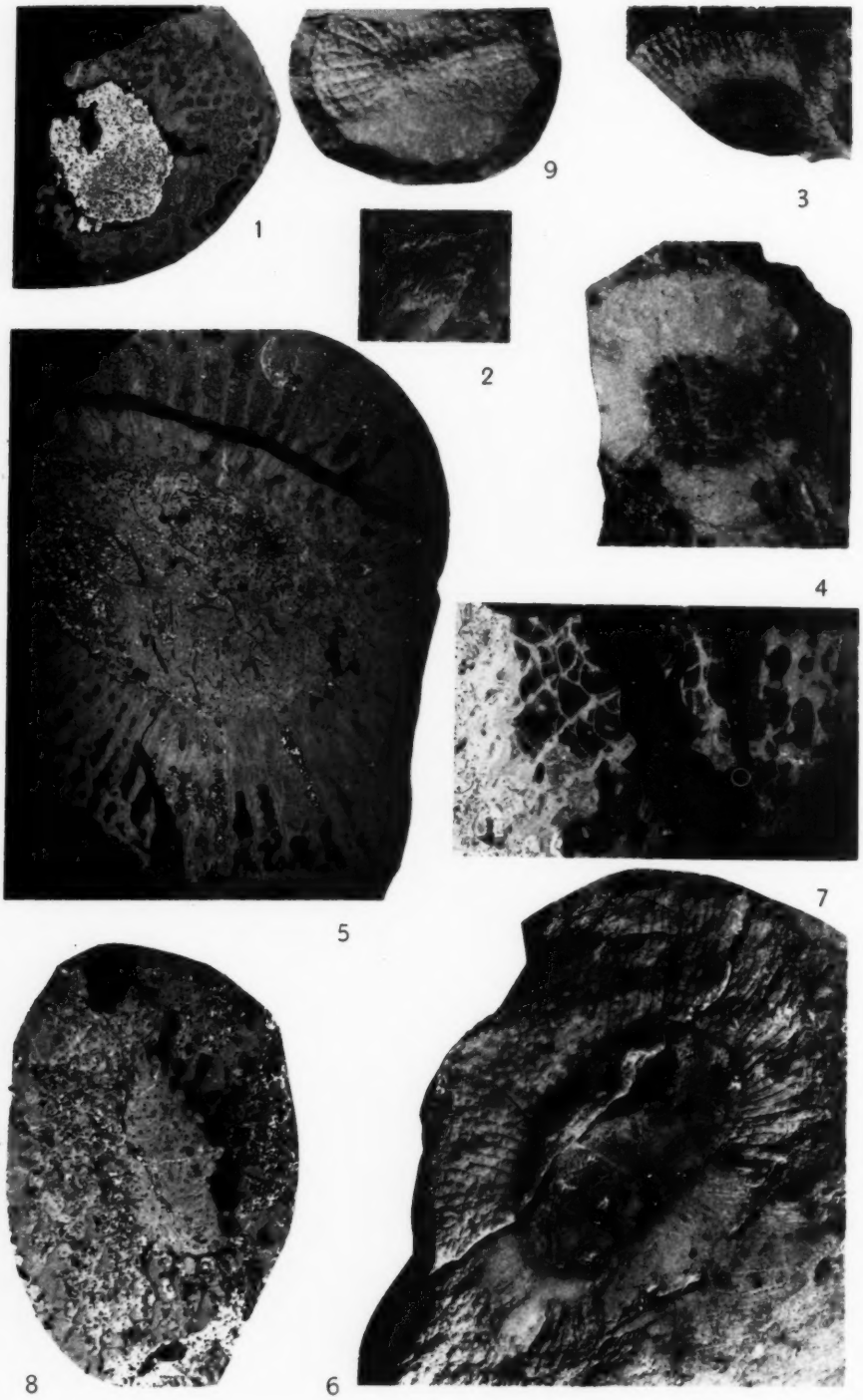
2, 3—*Pycnoidocoscinus rectiporus* Okulitch, n. sp. *2*, Holotype, ×6. No. 6, University of British Columbia. Enlarged portion of inner wall showing rectangular mesh made of horizontal and vertical elements. *3*, Holotype, ×1½, No. 6, University of British Columbia. General view showing naturally weathered longitudinal section of the specimen. Parieties and tabulae visible, as well as the thickened corrugated outer wall. (p. 348)

4, 5—*Eucyathus obliquus* Okulitch, n. sp. *4*, Holotype, ×3. No. 13, University of British Columbia. Longitudinal thin section, showing intervallum structures. *5*, Holotype, ×3. No. 13, University of British Columbia. Oblique transverse thin section, showing porous inner wall, tabulae, parieties, and dissepiments. (p. 347)

6—*?Copleicyathus laminosus* Okulitch, n. sp., Holotype, ×6. No. 14, University of British Columbia. Transverse thin section, exposing central cavity, inner wall, intervallum with taeniae and dissepiments, and portions of outer wall. Inner wall marked IW, central cavity CC, and outer wall OW. (p. 345)



Okulitch, Lower Cambrian Pleospongia



Okulitch, Lower Cambrian Pleospongia

cyathus. The nearest relative is probably *Pycnoidocoscinus pycnoideum* Bedford (1936) from the Lower Cambrian of Australia. The present specimen differs from it specifically in a different intervallum coefficient, flatter tabulae, and flattened loculi.

Holotype.—No. 6, V. J. Okulitch collection, University of B. C.

Horizon and locality.—Lower Cambrian, Donald formation. South side of Holt Creek, Dogtooth Range, near Golden, B. C.

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A LOWER PERMIAN AMMONOID FAUNA FROM NEW MEXICO

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ABSTRACT—Representatives of the following six ammonoid genera are illustrated and described from the middle portion of the Hueco formation at three adjacent localities in south-central New Mexico: *Medlicottia*, *Metalegoceras*, *Thalassoceras*, *Peritrochia*, *Properrinites*, and a new genus termed *Bransonoceras*. The assemblage resembles that known from the Hueco, Wolfcamp, Admiral, and particularly the Clyde formations of Texas, and it is indicative of the Lower Permian.

RECENTLY Dr. Carl C. Branson sent us for study several collections of cephalopods that he and Mr. J. S. Baker had assembled from three rather closely adjacent localities some 35–38 miles south of Alamogordo, Otero County, New Mexico. Many of the specimens are well preserved, and they represent a considerable variety of both nautiloids and ammonoids and seem to merit particular attention. An account of the nautiloids is being included by Miller and Youngquist in a monograph of American Permian forms that they are preparing, and therefore we are limiting our discussion to the ammonoids.

Dr. Branson has written us that these ammonoids came from

> about 900 feet above the base of the Hueco (marked by the Powwow conglomerate a few miles to the north) in a sequence of alternating green silty shales, buff siltstones, and dolomitic limestones constituting the middle part of the Hueco. The upper part is of dense dolomitic limestones with green siltstones, overlain by 155 feet of gypsum with minor amounts of limestone and with some siltstone near the top. This gypsum also appears to be referable to the Hueco. Above the gypsum is the Abo in the restricted sense, that is, the red shales and siltstones. It is the old Abo exclusive of the Bursum and probably including what has been lately called the Meseta Blanca member of the Yeso, not here separable. Typical Yeso overlies the red beds. As you can see, I have definite proof that the Hueco underlies the Abo; does not merge with it as has been stated.

Altogether, the collections under consideration contain the following six ammonoid species:

Medlicottia sp.
Metalegoceras baylorense (White)
Thalassoceras welleri (Böse)
Bransonoceras bakeri, n. gen. and sp.
Peritrochia novomexicana, n. sp.
Properrinites sp.

Three of the genera represented (*Metalegoceras*, *Peritrochia*, and *Properrinites*) are known to occur also in the lower part of the Hueco limestone at the southern end of the Hueco Mountains in west Texas (some 50 miles to the south), in the lower part of the Wolfcamp formation of the Glass Mountain region also in west Texas (almost 200 miles southeast of the Huecos), and in the Admiral and the Clyde formations of north-central Texas. Furthermore, the upper part of the Wolfcamp has yielded *Peritrochia*, *Properrinites*, and *Thalassoceras welleri;* and the Clyde carries *Medlicottia*. *Peritrochia* has a long stratigraphic range in the late Paleozoic; but *Metalegoceras* is limited to the lower half of the Permian (Wolfcamp and Leonard series), and *Properrinites* is believed to be characteristic of the Lower Permian. Although *Medlicottia* has not been reported from the Hueco, Wolfcamp, or Admiral formations of Texas, it is known to occur in the Clyde formation of north-central Texas and in the Sakmarian beds of the Ural region in Soviet Russia, both of which belong in the Lower Permian series. In summary, then it can be said that the ammonoids we are studying clearly indicate a Lower Permian age for the containing beds and that none of them is incompatible with that assignment. Furthermore, it is our understanding that J. Brookes Knight has examined the gastropods that occur in association with these ammonoids and found that they likewise are suggestive of the Lower Permian. James Steele Williams has written that the brachiopods reinforce this

conclusion, and the nautiloids are, to say the least, in harmony with it.

Finally, it should be mentioned that the representative of *Properrinites* we are studying seems to be somewhat more advanced than the congeneric forms known from the lower Hueco, lower Wolfcamp, and Admiral formations of Texas, but it is in about the same stage of development as *P. cumminsi* (White) of the Clyde and probably the upper Wolfcamp. The Clyde carries in common with the fauna under consideration at least one good species, *Metalegoceras baylorense* (White). Also, the small fragment of a medlicottid that we have from the Hueco of New Mexico may well be referable to *Medlicottia copei* White of the Clyde, and our *Peritrochia novomexicana* is fairly close to *P. electraensis* (Plummer and Scott) of the same formation. However, no representatives of *Thalassoceras* have been recorded from the Clyde; and it should be emphasized that *T. welleri* (which occurs in the Hueco fauna under consideration) has been found in only the upper part of the Wolfcamp, and that most of the ammonoids known from that formation were obtained near its base. Therefore, from a study of the cephalopods alone, it can be said that although the evidence is not very conclusive, the available data seem to suggest that the ammonoid-bearing beds of the Hueco in New Mexico are slightly younger than those of the same formation, the lower Wolfcamp, and the Admiral of Texas, and are probably of about the same age as the upper Wolfcamp of west Texas and the Clyde formation of north-central Texas. After we had reached this conclusion, C. C. Branson wrote us that also "evidence from fusulinids indicates that equivalents of the earlier beds of the Wolfcamp of the Glass Mountains do not occur . . . in southern New Mexico."

FOSSIL LOCALITIES

The ammonoids on which this report is based came from three localities in T. 22 S., R. 10 E., Otero County, New Mexico: (1) near the center of sec. 9, (2) in a west-facing escarpment between two small east-west faults in the NE¼ sec. 15, and (3) along a strike wash on both sides of the saddle in the hill just north of the south line of sec. 20, at the center of the SW¼, on the McGregor ranch about ½ mile west and south of Little Crockett tank (Clover tank on U. S. Grazing Service map). The first of these localities yielded *Thalassoceras welleri* and *Peritrochia novomexicana;* the second, *Metalegoceras baylorense* in abundance and *Properrinites* sp.; and the third, at least one representative of all of the forms described in this report except *Metalegoceras baylorense.*

C. C. Branson has written us that the "locality in section 20 is definitely the same horizon as that in section 9," but in the former the cephalopods occur in and above the *Dictyoclostus* bed whereas in the latter they were found in and just below that bed. At both of these localities *Dictyoclostus, Derbya,* and bellerophontids are abundant, *Composita* and lamellibranchs are common, and *Meekella* is rare. At the locality in section 15, only certain lamellibranchs occur with the cephalopods, and the fossiliferous beds are believed to be about "50 to 100 feet lower stratigraphically than the *Dictyoclostus* bed."

ACKNOWLEDGMENTS

All of the specimens on which this study is based were collected in 1946 by Dr. C. C. Branson and Mr. J. S. Baker of the Shell Oil Company, and they were sent to us through the courtesy of Dr. Branson, who also supplied us with detailed data in regard to their occurrence and who read and criticized our manuscript. The photographs that accompany this report were retouched by Mr. Howard Webster, and he also made the suture drawings. The completion of the manuscript and the illustrations was made financially possible by the Graduate College of The State University of Iowa. For all of this assistance, we hereby acknowledge our indebtedness.

SYSTEMATIC PALEONTOLOGY

MEDLICOTTIA sp.

Plate 57, figures 1, 2

The only medlicottid in the collections under consideration is a single small fragment representing the ventral portion of a moderately large individual. The lateral zones of this specimen converge ventrally, and the conch was therefore lenticular in shape though there was a rather prominent groove along the venter. The ventrolateral

margins are somewhat worn, but there seems to be a faint suggestion of low nodes on them. The preserved portions of the sutures show that they were rather far advanced, for the first lateral saddles are relatively narrow and at least three or four small lobes or digits are present on each of their flanks.

All of these characters indicate that this specimen belongs in *Medlicottia*, to which it is being referred. In west Texas no representatives of that genus have been reported from strata older than the Middle Permian (Leonard); but some have been described from the Lower Permian Clyde formation of north-central Texas and the Sakmarian beds of the Ural region, which are believed to be in part, at least, contemporaneous with the Hueco and the Wolfcamp.

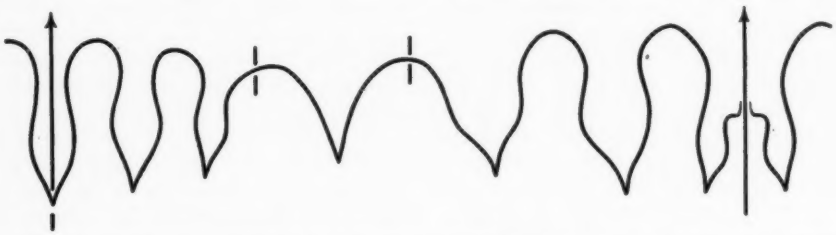

FIG. *1*—Diagrammatic representation of a mature suture of *Metalegoceras baylorense* (White), based on several specimens from the mid-portion of the Hueco formation in New Mexico, ×1¼.

Occurrence.—Mid-portion of Hueco formation on the McGregor ranch about ⅔ mile west and south of Little Crockett tank along a strike wash on one side of the saddle in the hill just north of the south line of sec. 20, at the center of the SW ¼, T. 22 S., R. 10 E., Otero County, New Mexico.

Repository.—U. S. National Museum.

METALEGOCERAS BAYLORENSE (White)
Plate 56, figures 1–4

Goniatites baylorensis WHITE, 1891, U. S. Geol. Surv. Bull. 77, pp. 16, 19, pl. 2, figs. 1–3.

Paralegoceras baylorense SMITH, 1903, U. S. Geol. Surv. Mon. 42, pp. 16, 89, 99–100, 145, pl. 4, figs. 9–11; BÖSE, 1919 [1917], Texas Univ. Bull. 1762, pp. 25, 207; SMITH, 1927, Mijnw. Nederlandsch-Indië Jaarb., Jaarg. 55 (1926), Verh. 1, p. 30; KING, 1931 [1930], Texas Univ. Bull. 3042, p. 19.

Metalegoceras baylorense MILLER, 1932, Am. Jour. Sci., 5th ser., vol. 24, p. 438; PLUMMER and SCOTT, 1937, Texas Univ. Bull. 3701, pp. 20, 28, 30, 281, 283, 284–286, 287, 395, 399, text fig. 88 (opp. p. 402), pl. 21, figs. 8–13; MILLER and FURNISH, 1940, Geol. Soc. Am., Spec. Pap. 26, pp. 19, 20.

At a single locality in New Mexico, the Hueco formation yielded more than 20 representatives of this species, two of which we are figuring—the unfigured ones are fragments that represent relatively small portions of the conch. All are internal molds that are completely septate.

The individual represented by figures 1–3 on plate 56 is about 90 mm. in diameter, and near its adoral end its conch is about 55 mm. wide and 30 mm. high. The largest of the associated fragmentary specimens appears to have been of the order of 25 to 35 per cent larger than this one. The maximum diameter of the specimen illustrated by figure 4 on plate 56 measures about 92 mm.

The whorls are low and broad and are more or less helmet-shaped in cross section as they are broadly rounded ventrally, ventrolaterally, and laterally, abruptly rounded dorsolaterally, and impressed dorsally. The umbilicus is rather small for this genus, but it is deep. The maximum diameter of the umbilicus of the smaller of the figured specimens measures about 34 mm. The umbilical

EXPLANATION OF PLATE 56

FIGS. *1–4*—*Metalegoceras baylorense* (White). Two specimens—figures *1–3* represent one individual—from the mid-portion of the Hueco formation in the NE ¼ sec. 15, T. 22 S., R. 10 E., Otero County, New Mexico, slightly less than ×1. (p. 352)

Miller and Parizek, New Mexico Permian Ammonoids

Miller and Parizek, New Mexico Permian Ammonoids

shoulders are abruptly rounded and the umbilical walls are steep but stepped.

Each suture forms a large prominently bifid ventral lobe (the prongs of which are asymmetrically hastate and are acuminate), and on either side of it a high U-shaped but very narrowly rounded first lateral saddle (which is distinctly constricted near its mid-height), a more or less spatulate acuminate first lateral lobe, a second lateral saddle that is similar to the first but has a broader base, a second lateral lobe that is similar to the first but is shorter and wider, a broader lower rounded saddle that extends across the umbilical shoulder, a shorter V-shaped lobe on the umbilical wall, a saddle which extends across the umbilical seam and which is similar to the one that extends across the umbilical shoulder but is not quite as high, an internal second lateral lobe that is similar to the external lateral lobes but is smaller and much narrower, a high rounded more or less U-shaped internal second lateral saddle that is constricted near its mid-height, an internal first lateral lobe which is similar to the internal second lateral lobe but is larger and longer, and an internal first lateral saddle which is similar to the internal second lateral saddle but is larger and higher and which extends to the long narrow acuminate spatulate dorsal lobe.

Remarks.—The specimens from New Mexico that we are referring to this species seem to be very closely similar to the holotype and to the topotypes illustrated and described by Plummer and Scott. The holotype is only about 45.5 mm. in diameter, but some of the topotypes are stated to reach "a diameter of more than a hundred millimeters."

This species does not seem to resemble very closely any of the congeneric forms that have been described from America. It is, however, similar to *M. tschernyschewi* (Karpinsky) of the Artinskian of the Ural region and possibly the Bitauni beds of Timor; and it is particularly close to *M. australe* (Smith) of the Bitauni beds of Timor.

Occurrence.—Abundant in the mid-portion of the Hueco formation in a west-facing escarpment between two small east-west faults in the NE ¼ sec. 15, T. 22 S., R. 10 E., Otero County, New Mexico. The holotype and the topotypes described by Plummer and Scott came from a limestone about the middle of the Clyde formation in the outcrop at the "Old Military Crossing" of the Big Wichita River in Baylor County, north-central Texas.

Repository.—U. S. National Museum (Hueco specimens)—the holotype is at the same institution, but the topotypes studied by Plummer and Scott are at the Bureau of Economic Geology of The University of Texas.

THALASSOCERAS WELLERI (Böse)
Plate 57, figurs 3–6

Prothalassoceras welleri BÖSE, 1919 [1917], Texas Univ. Bull. 1762, pp. 18, 35, 104–106, pl. 5, figs. 14–18; SCHUCHERT, 1927, Am. Jour. Sci., 5th ser., vol. 14, pp. 393–394; KING and KING, 1928, Texas Univ. Bull. 2801, p. 126; MILLER 1930, Jour. Paleontology, vol. 4, p. 408; KING, R. E., 1931 [1930], Texas Univ. Bull. 3042, pp. 7, 8; SELLARDS, 1932, Texas Univ. Bull. 3232, p. 149; KING, P. B., 1934, Geol. Soc. America Bull., vol. 45, p. 730, pl. 103; MILLER and OWEN, 1937, Jour. Paleontology, vol. 11, p. 420; PLUMMER and SCOTT, 1937, Texas Univ. Bull. 3701, pp. 22, 32, 352, 353, 354, 356–357, 358, text fig. 88 (opp. p. 402), pl. 36, figs. 1–3.

Thalassoceras welleri SMITH, 1929, Am. Jour. Sci., 5th ser., vol. 17, p. 76; MILLER and FURNISH, 1940, Geol. Soc. America Spec. Pap. 26, pp. 13, 21, 104, 105, 106, 107; MILLER, 1944, Geol. Soc. America Spec. Pap. 52, pp. 93, 94.

The collections being studied contain two specimens that belong in the Thalassocera-

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EXPLANATION OF PLATE 57

The specimens illustrated on this plate are from the mid-portion of the Hueco formation in the SW ¼ sec. 20 (figs. *1, 2, 5, 6, 9*), the center sec. 9 (figs. *3, 4*), and the NE ¼ sec. 15 (figs. *7, 8*), T. 22 S., R. 10 E., Otero County, New Mexico.

FIGS. *1, 2*—*Medlicottia* sp. Two views of a small portion of an internal mold of a phragmacone, ×3. (p. 351)

3–6—*Thalassoceras welleri* (Böse). Ventral and lateral views of two specimens, ×2 (figs. *3, 4*) and ×1½ (figs. *5, 6*) (p. 353)

7–9—*Properrinites* sp. Two specimens—figures *7, 8* represent one individual—, both ×2. (p. 357)

tidae. Both are only moderately well preserved, but they seem to be referable to *Thalassoceras welleri* (Böse), which was originally described from the Wolfcamp formation of the Glass Mountains in west Texas.

The specimens under consideration are internal molds that are completely septate and therefore represent only phragmacone. The maximum diameter of the most nearly complete individual (pl. 57, figs. 5, 6) measures about 35½ mm. Near its adoral end its conch is about 20 mm. high and about 16 mm. wide. The specimen as a whole is subdiscoidal in shape as the whorls are compressed laterally, higher than wide, flattened laterally, rounded ventrally, and deeply impressed dorsally. The umbilicus is small and that of the specimen just mentioned attains a diameter of only some 3 mm. The umbilical shoulders are low, rounded, and inconspicuous.

Each external suture forms a very large prominently bifid ventral lobe, and on either side of it a U-shaped first lateral saddle, a more or less V-shaped asymmetrical first lateral lobe, and a relatively low broadly rounded second lateral saddle that extends to the umbilicus. The prongs (subdivisions) of the ventral lobe and the first lateral lobe are prominently denticulate.

Remarks.—Even the details of the denticulation of the lobes of the external sutures of the specimens under consideration do not seem to differ essentially from those of the holotype of *T. welleri*. That individual was regarded by Böse as the type specimen of a genus for which he coined the name *Prothalassoceras*, but Miller and Furnish (1940, p. 104) have suppressed that name as a synonym of *Thalassoceras* Gemmellaro. It should also be mentioned that Böse believed the beds from which his specimen came to be part of the Hess formation, but they are now regarded as belonging in the Wolfcamp formation.

Occurrence.—Both of the specimens under consideration came from the mid-portion of the Hueco formation in T. 22 S., R. 10 E., Otero County, New Mexico. The more nearly complete individual is from the McGregor ranch about ¾ mile west and south of Little Crockett tank along a strike wash on one side of the saddle in the hill just north of the south line of sec. 20, at the center of the SW ¼. The second Hueco specimen, a fragment representing the ventral part of one volution of the phragmacone (pl. 57, figs. 3, 4), came from the so-called "*Dictyoclostus* bed" near the center of sec. 9. The only other known representatives of this species are from the upper part of the Wolfcamp formation at two localities in the Glass Mountain region of west Texas: (1) near the base of the Glass Mountain escarpment north of the Decie Ranch house, and (2) on the south side of Dugout Mountain.

Repository.—U. S. National Museum (Hueco specimens).

Genus BRANSONOCERAS
Miller and Parizek, n. gen.
Genotype: *Bransonoceras bakeri* Miller and Parizek, n. sp.

This genus is being established for a single specimen. The generic name is given in honor of Dr. Carl C. Branson, through whose courtesy this specimen became available for study.

The new genus can be diagnosed as follows: Conch moderately small and thickly subdiscoidal in shape. Whorls depressed dorsoventrally, broadly rounded laterally and particularly ventrally, and impressed dorsally. Umbilicus large and open. Surface of test bears numerous prominent transverse rounded ribs that are of about the same size and shape as the intermediate grooves. At maturity each external suture forms a broad prominently bifid ventral lobe and on either side of it a large V-shaped first lateral lobe and two small undivided pointed lobes, one outside and one inside the umbilical shoulder; these lobes are all separated by rounded saddles.

This genus seems to be related to *Doryceras* Gemmellaro and *Texoceras* Miller and Furnish, and, like them, it should be placed in the Adrianitidae of Schindewolf. The genotype of *Doryceras*, *D. fimbriatum* Gemmellaro of the upper Middle Permian Sosio beds of Sicily, is known from only small specimens, all of which may well be immature. Insofar as shape and ornamentation of conch and size of umbilicus are concerned, this genotype resembles that of *Bransonoceras* rather closely. Also, at least its external sutures consist of the same number of ele-

ments; but the second lateral lobe in the Sicilian species is much larger than is that in the form under consideration. It seems probable that the similarity between these two genotypes is more apparent than real. Nevertheless, if the internal sutures should prove to consist of the same number of elements in each case, *Bransonoceras* may have to be suppressed as a synonym of *Doryceras*.

Only one species is known that belongs in *Texoceras*, *T. texanum* (Girty) of the lower Middle Permian Bone Spring limestone of west Texas. That form has a small umbilicus, and the surface of its test is reticulate. In general its external sutures resemble those of *Bransonoceras*, but the lobes are rounded rather than pointed.

The only known representative of the new genus *Bransonoceras* was found in the mid-portion of the Lower Permian Hueco formation of southeastern New Mexico.

BRANSONOCERAS BAKERI
Miller and Parizek, n. sp.
Plate 58, figures 1–3

Holotype is only moderately well preserved, and it retains most of its test, or a replacement of it. The conch is rather small and is thickly subdiscoidal in shape. The whorls are low helmet-shaped in cross section as they are depressed dorso-ventrally and are broadly rounded laterally and particularly ventrally, and impressed dorsally. The maximum diameter of the holotype measures about 25 mm., and near its adoral end its conch is about 8½ mm. high and 14 mm. wide. The conch is expanded orad rather gradually, and near the adapical end of the outer volution of the holotype its height and width measure about 5½ mm. and 9½ mm., respectively.

The umbilicus is large and open, and the maximum diameter of that of the holotype measures about 13 mm. The umbilical shoulders are abrupt, and the umbilical walls are steep.

The surface of the test bears numerous prominent rounded transverse ribs, which are of about the same size and shape as the intermediate grooves. There are about 30 of these ribs in the adoral half-volution of the conch of the holotype.

Most of the adoral quarter-volution of the holotype is non-septate and presumably therefore represents living chamber. The adoral camera of the holotype is much shorter than the preceding one, indicating that the specimen represents a fully mature individual. As shown by text figure 2, each mature external suture consists of a broad prominently bifid ventral lobe, and on either side of it a large high U-shaped first lateral saddle, a large V-shaped first lateral lobe, a low rounded asymmetrical second lateral saddle, a small pointed lobe that centers just outside the umbilical shoulder, a low rounded saddle, and a moderately small V-shaped lobe on the umbilical wall.

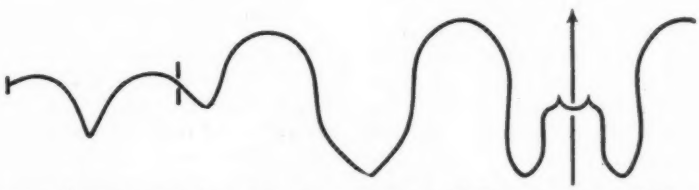

FIG. 2—Diagrammatic representation of an external suture of *Bransonoceras bakeri*, n. sp., based on the holotype at a diameter of almost 20 mm., ×5.

Remarks.—Although this form is superficially similar to *Doryceras fimbriatum* Gemmellaro of the Sosio beds of Sicily, its sutures are different. In the Sicilian species, the second lateral lobe of the sutures is only slightly smaller than the first lateral lobe, and it is considerably larger than the lobe immediately dorsad of it.

The specific name is given for Mr. J. S. Baker of the Shell Oil Co., who, in company with Dr. Carl C. Branson, found the only known representative of this species.

Occurrence.—Mid-portion of the Hueco formation on the McGregor ranch about ¾ mile west and south of Little Crockett tank along a strike wash on one side of the saddle

in the hill just north of the south line of sec. 20, at the center of the SW ¼, T. 22 S., R. 10 E., Otero County, New Mexico.

Holotype.—U. S. National Museum.

PERITROCHIA NOVOMEXICANA
Miller and Parizek, n. sp.
Plate 58, figures 4–9

At two outcrops of the Hueco formation of New Mexico, 17 conspecific specimens were collected that seem to be referable to the genus *Peritrochia*. However, they are distinct from all previously described species and therefore a new specific name is being introduced for them.

All of these specimens are internal molds, two (and part of a third) of which are illustrated. The rest represent varying degrees of preservation, from fragments showing relatively small portions of the conch to nearly complete specimens. The living chamber occupied approximately one full volution of the conch.

The specimen illustrated by figures 4–6 on plate 58 is designated the holotype. It is about 20 mm. in diameter, and near its adoral end the conch is about 11¼ mm. high and 10½ mm. wide. Although the holotype is representative of the average magnitude of the specimens, two of the near-complete paratypes and one of the fragmentary specimens are larger. The largest (pl. 58, figs. 7, 8), which is somewhat distorted, attains a diameter of about 35 mm., and near its adoral end the height and width of its conch measure about 20 mm. and 17 mm., respectively.

The conch is subdiscoidal and the whorls are helmet-shaped in cross section. The whorls are rounded ventrally and ventrolaterally, flattened laterally, broadly rounded dorso-laterally, and deeply impressed dorsally. The umbilicus is small and inconspicuous, and, at least at maturity, is closed. The umbilical shoulders are broadly rounded and indefinite.

Each external suture forms a prominently bifid ventral lobe (with slightly curved prongs) and on either side of it three U-shaped saddles and three trifid lobes followed by a relatively low broad saddle that extends to the umbilicus.

FIG. 3—Diagrammatic representation of an external suture of *Peritrochia novomexicana*, n. sp., based on the holotype at a diameter of about 18 mm., ×5.

Several of the paratypes retain portions of the test. These show that the surface bears numerous fine lines that are essentially straight and directly transverse to the long axis of the conch (pl. 58, fig. 9).

Remarks.—This form is similar to *Peritrochia sellardsi* (Plummer and Scott), *P. ganti* (Smith), and *P. electraensis* (Plummer and Scott). In the first two of these species the umbilicus is relatively large and prominent, and in all three the external sutures form an additional lobe on each side of the conch between the venter and the umbilicus. All four of these species are close. Attention should be called to the fact that in the adoral portion of the phragmacone of the larger of the Hueco specimens, the sutures are closely spaced, indicating that they represent fully mature individuals.

Occurrence.—All of the type specimens of this species are from the mid-portion of the Hueco formation. Fourteen of them, including the holotype, were collected on the McGregor ranch about ¾ mile west and south of Little Crockett tank along a strike

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EXPLANATION OF PLATE 58

The specimens illustrated on this plate are from the mid-portion of the Hueco formation in the SW ¼ sec. 20 (figs. *1–6, 9*) and the center sec. 9 (figs. *7, 8*), T. 22 S., R. 10 E., Otero County, New Mexico.

FIGS. *1–3*—***Bransonoceras bakeri*** Miller and Parizek, n. sp. Three views of the holotype, ×2. (p. 355)

4–9—***Peritrochia novomexicana*** Miller and Parizek, n. sp. The holotype (figs. *4–6*), a large paratype (figs. *7, 8*), and an enlargement of the lateral zone in the adoral portion of a testiferous specimen about the same size as the holotype (fig. *9*), ×2 (figs. *4–8*) and ×5 (fig. *9*). (p. 356)

1

2

3

4

5

6

7

9

8

Miller and Parizek, New Mexico Permian Ammonoids

wash on both sides of the saddle in the hill just north of the south line of sec. 20, at the center of the SW ¼, T. 22 S., R. 10 E., Otero County, New Mexico. Three paratypes (including the one represented by figures 7 and 8 on plate 58) came from just below the "*Dictyoclostus* bed," at the center of sec. 9, T. 22 S., R. 10 E., Otero County, New Mexico.

Repository.—U. S. National Museum.

PROPERRINITES sp.
Plate 57, figures 7–9

Two perrinitids have been found in the Hueco formation of New Mexico. Their preservation leaves much to be desired; but both belong in the genus *Properrinites*, and presumably they are conspecific. The maximum diameter of the more nearly complete specimen (pl. 57, figs. 7, 8) measures about 29 mm., and near its adoral end (where the conch seems to be worn and only slightly crushed) the height and width of conch measure about 16 mm. and 14 mm., respectively. The umbilicus of this specimen is about 6 mm. in diameter. The sutures are clearly of a primitive perrinitid type, but their details seem to have been lost as a result of natural solution to which the specimen appears to have been subjected.

The other Hueco specimen (pl. 57, fig. 9) is an internal mold of the ventral portion of part of one volution. As shown by text figure 4, it reveals the shape of a segment of the sutures, which seem to be typical of *Properrinites*.

Remarks.—The conch of the individual represented by figures 7 and 8 on plate 57 appears to be relatively narrow for this genus. However, its shape has been modified by crushing and solution and/or abrasion, and the other Hueco specimen seems to be much more broadly rounded ventrally. Because of the rather poor preservation and incompleteness of the specimens under consideration, it is difficult if not impossible to determine their specific affinities. However, the portion of their sutures that can be ascertained in detail shows that the middle Hueco form is farther advanced than *P. bösei* (Plummer and Scott) of the Admiral formation of north-central Texas, *P. bakeri* (Plummer and Scott) of the lower Wolfcamp of west Texas, and *P. plummeri* Elias probably of the Big Blue series of Kansas; and that it is in about the same stage of development as *P. mooreae* Miller and Furnish of the lower portion of the Cibolo formation of west Texas and *P. cumminsi* (White) of the Clyde formation of north-central Texas and probably the upper Wolfcamp of west Texas (King, 1931, p. 7). In certain respects, *P. cumminsi* seems to be even more advanced than the Hueco form and *P. mooreae* appears to be more primitive.

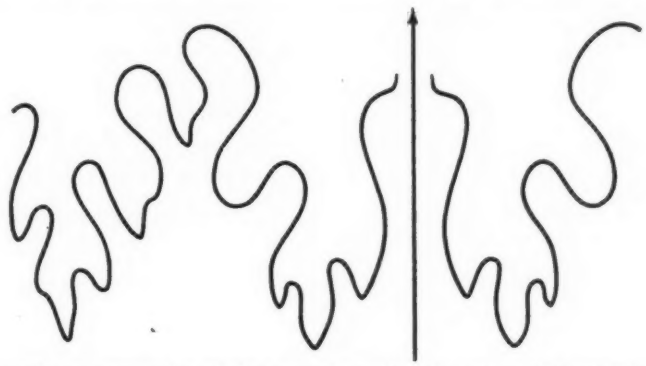

FIG. 4—Diagrammatic representation of the ventral portion of a suture of *Properrinites* sp., based on the specimen represented by figure 9 on plate 57, ×5.

Occurrence.—Both specimens are from the mid-portion of the Hueco formation in T. 22 S., R. 10 E., Otero County, New Mexico. The one illustrated by figures 7 and 8 on plate 57 was found in association with numerous representatives of *Metalegoceras baylorense* in a west-facing escarpment be-

tween two small east-west faults in the NE ¼ sec. 15; and that represented by figure 9 on the same plate came from the McGregor ranch about ½ mile west and south of Little Crockett tank along a strike wash on one side of the saddle in the hill just north of the south line in sec. 20, at the center of the SW ¼.

Repository.—U. S. National Museum.

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MANUSCRIPT RECEIVED AUGUST 1, 1947

JOURNAL OF PALEONTOLOGY, VOL. 22, NO. 3, PP. 359–361, PL. 59, MAY 1948

A SMALL AMPHIBIAN FROM THE TRIASSIC OF HOWARD COUNTY, TEXAS

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A SKULL and lower jaw of a small amphibian were discovered in 1940, while Works Projects Administration workers were excavating a *Trilophosaurus* quarry in Howard County, Texas. Unfortunately the specimen was cleaned by a too enthusiastic preparator who removed much of the roofing bone, the articular surfaces of the exoccipitals and parts of the palate and occiput. The photographs show the condition of the skull but perhaps make it appear better preserved than it really is. The position of the fragments of the sutures which may be accurately determined are indicated in the photographs. The skull has been immersed in various liquids in hope that more of the suture pattern could be determined, but without success.

The specimen was loaned to me through the courtesy of Dr. E. H. Sellards, Director of the Texas Memorial Museum and Dr. John T. Lonsdale, Director of the Bureau of Economic Geology.

Order LABYRINTHODONTIA
Suborder STEREOSPONDYLI ?
Family LATISCOPIDAE Wilson, new family

An analysis of the determinable characters of the species indicates that it is sufficiently distinct to warrant the erection of a new family as well as a new genus. The family characters present are necessarily those of the genus.

Genus LATISCOPUS Wilson, new genus

Characters.—Skull small, highly arched, triangular, not ornamented; parasphenoid broadly joined to the pterygoids, cultriform process broad, occipital condyles double (?), teeth conical, large pulp cavity; cornua absent, otic notch very small, orbits large, lateral and laterally directed.

Genotype.—*Latiscopus disjunctus* Wilson, new genus and species.

LATISCOPUS DISJUNCTUS
Wilson, new species
Plate 59, figures 1–4

Holotype.—Uncrushed skull and lower jaw, no. 31025–182 in the collection of the Bureau of Economic Geology, The University of Texas.

Locality.—Quarry 1, (See Gregory, 1945, pp. 273–359); southeast corner of sec. 58. block 29, Waco and Northeastern Railroad Company Survey, about 3 miles north of Otis Chalk, Texas.

Formation.—Dockum group, Upper Triassic.

DESCRIPTION

Skull roof.—The skull roof is highly arched, a character which is in sharp contrast to the broad flat skulls of the larger Triassic amphibians. Measured from the articular surfaces of the quadrates the skull height is half the breadth and the occipital height is one-third the skull breadth. The orbits are large, lateral, laterally directed and located approximately on or slightly anterior to the midlength of the skull. A parietal foramen is present although its size and outline cannot accurately be determined. The position, size and shape of the nares is wholly conjectural. The extent of the cornua is unknown but it is believed that they were small with little or no otic notch. No evidence for the presence of ornamentation or sensory canals can be found.

Suggested outlines of parietal, dermsupraoccipital, ?supratemporal, and tabular are all that can be seen of the skull roof pattern.

One would normally expect to find a complete skull roof in an Upper Triassic stereospondyl but in the position of the reptilian temporal openings there is no bone. Whether or not bone at one time covered this area it is impossible to say. The skull is unquestionably that of an amphibian because of the

structure of its palate and occiput. A complete account of the temporal region will have to await further discoveries.

Palate.—The ventral surface of the palate is fairly well preserved in the posterior region. There is a broad parasphenoid suturally joined to the pterygoids. The extreme posterior end of the parasphenoid is missing but there is good evidence in the broken edges of the bone that it at one time covered the ventral surface of the exoccipitals. A projection of the base of the cultriform process anteriorly shows that this structure was rather broad.

The pterygoid has three processes, one anterolateral, the other posterolateral and the third vertical. Only the last two are sufficiently well preserved to show their true relationships. The posterolateral quadrate ramus is broad and flat and unites laterally with a well ossified quadrate. From the anterior edge of the quadrate ramus of the pterygoid rises a broad thin *lamina ascendens* to join the skull roof.

Broken edges of the exoccipitals are exposed where the posterior margin of the parasphenoid was removed.

Occiput.—Whether the occipital condyle was double or single is now uncertain; there is reason to believe from the broken edges that it was double. The exoccipitals are Y-shaped, the dorsolateral process joins a descending process of the tabular, the dorsal process joins a descending process of the dermsupraoccipital. There is no evidence of ossified supra- or basioccipitals. The posttemporal fenestra is rather large for the size of the skull. The quadrates are well ossified.

Teeth.—There are about 27 teeth to a side, each approximately 1.5 mm. high. Each has a large pulp cavity, and shows no evidence of infolding.

Lower jaw.—Remnants of an articular, angular, dentary and splenial are identifiable in the lower jaws. No sutures are visible. The number of coronoids is uncertain.

TAXONOMIC POSITION

The broad ventral covering of the exoccipitals by the parasphenoid and the long sutural connection of the parasphenoid with the pterygoids together with its high stratigraphic position is most suggestive of the *Stereospondyli*. It is possible that *Latiscopus* might be a rachitome but since none have previously been found in the Dockum it is more likely that it is a stereospondyl. The discovery of associated vertebrae will prove or disprove this contention.

Latiscopus somewhat resembles morphologically the Trematosauridae. The skull is high, narrow and triangular and the interpterygoid vacuities are large. The resemblance seems to go no farther. The small vaulted skull is high anteriorly so that the orbits are directed laterally and not dorsally, and the parasphenoid-pterygoid suture is visible ventrally. The position of the orbits for lateral vision would tend to suggest that perhaps *Latiscopus* was not so closely adapted to a water habitat as the tremotosaurs and metoposaurs.

The possibility that this form might be a larval *Buettneria* has been rejected on the grounds that the proportions of the skull are entirely different and the well ossified quadrate and exoccipitals lead me to believe the form is an adult or nearly one.

At the present I do not feel there is sufficient evidence to do more than provisionally assign the Latiscopidae to the Stereospondyli.

Other forms found in association in the Otis Chalk area are:

Buettneria howardensis Sawin (1945)
Trilophosaurus buettneri Case (Gregory, 1945)
Angistorhinus sp.
Promystriosuchus sp.
Typothorax meadei Sawin (1947)
Coelophysis sp.

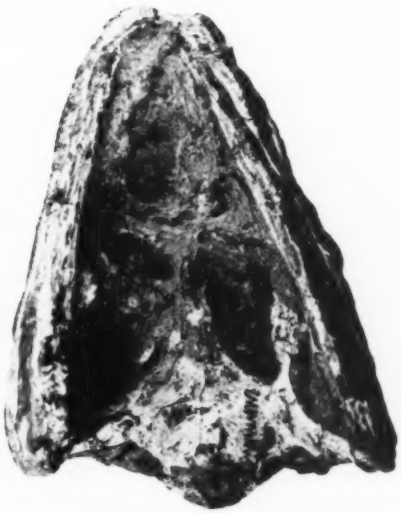
MEASUREMENTS

	mm.
Length of midline of skull	34.0
Breadth of posterior end	26.0
Breadth across center of orbits	18.0
Height from base of occiput	9.0
Height from quadrates	13.0
Height including lower jaws	16.5

EXPLANATION OF PLATE 59

FIGS. *1–4*—*Latiscopus disjunctus* Wilson, new genus and species. Bureau of Economic Geology, University of Texas. No. 31025-182. Dorsal, ventral, posterior and lateral views respectively. All views ×2. (p. 359)

1



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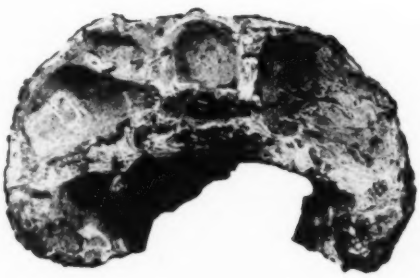

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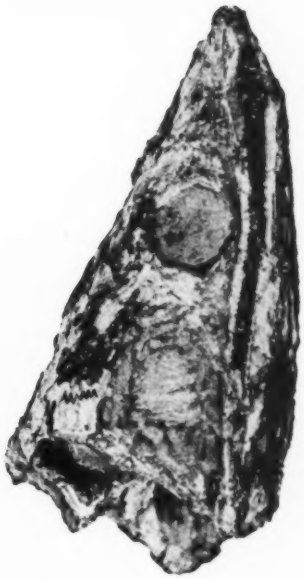

4

Wilson, Texas Triassic Amphibian

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JOURNAL OF PALEONTOLOGY, VOL. 22, NO. 3, PP. 362–364, PL. 60, MAY 1948

FOSSIL HELIOPORIDAE FROM JAPAN AND THE SOUTH SEA ISLANDS

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ABSTRACT—A new Lower Cretaceous coral, *Heliopora japonica* Eguchi, the oldest known representative of the genus, is described. The present day ecological conditions observed in the South Sea Islands are thought to be applicable to the Lower Cretaceous Coral formation of the Miyako Region, Iwate Prefecture, Japan.

ACKNOWLEDGMENTS

ACKNOWLEDGMENTS are made to the following: Professor Shoshiro Hanzawa, of the Institute of Geology and Paleontology, Tohoku Imperial University, Sendai, for permission to study the specimens preserved in that Institute; Dr. Hisakatsu Yabe, formerly Professor of the Tohoku Imperial University, Sendai, for the free use of his private library; and Mr. K. Kumagai, for his photographic work.

INTRODUCTION

The alcyonarian or octocorallian family Helioporidae, comprising a few genera, has a geological range from the Lower Cretaceous to Recent. *Heliopora japonica* Eguchi, to be described below, is a new example of its oldest representative, derived from the Lower Cretaceous of the Miyako Region in the Kitakami Mountainland, Iwate Prefecture. Notwithstanding its great antiquity, it differs very little from the living *Heliopora coerulea* (Pallas) of the coral seas of the Pacific. This latter species is also found as fossil in the young geological formations of Taiwan (Formosa), and has been recorded from the Cenomanian of England, and, as Recent, it is extensively distributed in the South Seas. The living species is here treated for comparison with the fossil form.

HELIOPORA COERULEA (Pallas)

Plate 60, figures 3, 4, 6

1762 *Corallium coeruleum* GRIMM, Acad. nat. curios., Dec. II, 1, ann. p. 408 (inaccessible, cited after Esper).

1766 *Millepora coerulea* PALLAS, Elenchus zoophytorum, p. 256 (inaccessible, cited after Esper).

1797 *Madrepora caerulea* ESPER, Fortestz. d. Pflanzenthiere. I, Th., p. 3, pl. 32, figs. 1, 2.

1821 *Pocillopora caerulea* LAMOUROUX, J., Exposition méthodique des genres de l'ordre des polypiers, p. 62, pl. 12, fig. 4, pl. 40 (56), figs. 1–3.

1833 *Heliopora coerulea* QUOY et GAIMARD, Voy. de l'Astrolabe. Zool., IV, Zooph., p. 252, pl. 20, figs. 12–14.

1834 *Heliopora coerulea* BLAINVILLE, Manuel d'Actinologie ou de Zoophytologie, p. 392, pl. 61, fig. 3.

1836 *Pocillopora coerulea* LAMARCK, Histoire des animaux sans vertébrés, II, p. 444.

1846 *Heliopora coerulea* DANA, Expl. Exped., Zooph., p. 540.

1860 *Heliopora coerulea* M.-EDWARDS et J. HAIME, Hist. Nat. corall. III, p. 231.

1879 *Heliopora coerulea* DUNCAN, On the Upper-Greensand coral fauna of Haldon, Devonshire: Geol. Soc. London Quart. Jour., vol. 35, p. 94, pl. 8, figs. 16–18.

1895 *Heliopora coerulea* BORNE, On the structure and affinity of *Heliopora coerulea:* Roy. Soc. London, Phil. Trans., vol. 186, p. 455.

1914 *Heliopora coerulea* FELIX, Anthozoa Palaeocretacea, Foss. Cat., I, Anim. Pars 6, p. 141 (with synonymy).

1927 *Heliopora coerulea* FAUSTINO, Recent Madreporaria of the Philippine Islands, p. 299.

This is a very common species in the shallow waters of the South Sea islands and Indian Ocean. It is found extensively on the reef flat of the outer barrier reefs of the Palau Islands, particularly where the current is strong; it occurs, too, in regions where the conditions are unsuitable for the growth of other reef-building corals. Clusters of this species are also found in the lagoons where current action is strong. It is distributed from the Okinawa and Ogasawara Islands at the north, south to the Indian Ocean, where it is said to be a very common species.

Many recent specimens of this blue coral from Ryûkyû, Ogasawara, Taiwan, and the South Sea islands were examined. They show manifold variation in the shape of

corallites, size and shape of autopores, and development of coenenchyma, but never exceed the limits of variation recognized by many previous authors.

Two different types of the species, in sections, are illustrated on the accompanying plate 60 (figs. 3 and 4). The coralla of this coral are frequently damaged by commensal or parasitic organisms, and one kind is shown in figure 3 by small circular pores which are not a part of the coral. In figure 5, pseudosepta are prolonged to the centers of autopores, which, according to Milne-Edwards and Haime, and, also, Gregory, is a characteristic feature of *Polytremacis;* in this form, autopores and siphonopores are respectively uniform in size and in distribution, while in the type shown by figure 4, autopores in two markedly different sizes have very short pseudosepta; thus, their interior is almost entirely vacant, as is usual in the typical examples of *Heliopora coerulea.*

In spite of these differences, the two types are thought to be specifically indistinguishable from the typical *Heliopora coerulea* (Pallas). Dana once distinguished two varieties of it, var. *tuberosa* and var. *meandrina*, based on the difference of the general shape of their corallum, but such differences are not worthy of specific or even subspecific distinction in this coral.

Holotype.—Exact place of preservation unknown.

Type locality.—Indian Ocean (Recent).

Age and Distribution.—Haldon, Devonshire, England; Cenomanian. Tjao, Bantam, Java (specimen in collection of Institute of Geology and Paleontology, Tohoku Imperial University, Reg. No. 65396); Pliocene. Malumbang limestone of Centabu, Cebu, Philippines (specimen in collection of Institute of Geology and Paleontology, Tohoku Imperial University, Reg. No. 65394); Pliocene. Van Rees Mountain, Dutch New Guinea; Pliocene. Fias limestone of Fias Island, Caroline Islands (specimen in Institute of Geology and Paleontology, Tohoku Imperial University, Reg. No. 63259). Ryûkyû limestone of Zyu-zan, Kaoiko, Sisito, Zinkosi, and Senzan, all in Takao Prefecture, Taiwan. Kaiko (specimens in Institute of Geology and Paleontology, Tohoku Imperial University, Reg. No. 55885), and Tyuzinkosi (specimen in Institute of Geology and Paleontology, Tohoku Imperial University, Reg. No. 37738), near Takao, Taiwan; Pleistocene. Geological Range: Cenomanian to Recent. Geographical Distribution: Pacific and Indian Ocean, restricted to tropical and subtropical regions in which coral reefs grow.

HELIOPORA JAPONICA Eguchi, n. sp.
Plate 60, figures 1, 2, 5, 7

Corallum massive or encrusting, surface gibbous or convex; sometimes ramose. The type specimen. which is 47 by 30 by 25 mm. in size and shows an aspect of two small spherical masses united, probably represents marginal lobes of a gibbous stock. Autopores circular, small, lacking proper walls, ¾ to 1 mm. in inner diameter, and provided with short pseudosepta or septal processes, number of them counted in 33

autopores being	13	14	15	16	17	18	19
	4	4	7	8	7	2	1

and, hence, the prevailing number is 15–17; 0.5–0.8 mm. distant, and usually separated by one or two rows of siphonopores which measure 0.2 mm. in breadth. Tabulae well developed, numbering two or three per 2 mm.

There is one very well preserved specimen and many worn fragments in the collection at my disposal. In some branching colonies, the autopores are more regularly arranged than in massive or encrusting forms, bend slightly upward, and are separated by broader intervals than in massive forms. These differences, however, apparently come within the range of variation, and these different forms are thus regarded as belonging to one and the same species. The present species in most respects agrees fairly well with the living blue coral, *Heliopora coerulea* (Pallas) from the South Sea islands (See plate 60, fig. 3). The main distinction between the two species lies in the different number of septa, and in the different sizes of autopores and siphonopores. In general, the recent species has better developed coenenchyma, though its amount varies locally, even in the same corallum.

Among the Cretaceous species, *Heliopora urgonensis* (Koby)[1] is nearest, but is distinguished by having slightly larger autopores, with wider intervals; moreover, the

range of variation in the number of pseudosepta in this species exceeds that in *H. japonica*, being 10–20 in the former and 13–19 in the latter. In the number of pseudosepta, *H. somaliensis* Gregory[2] from the Turonian of Somaliland, is almost identical. This and another ally, *H. edwardsi* Stoliczka[3] from the Cenomanian of South India and Dremisa of Greece,[4] are distinguished from it by having richer coenenchyma and larger autopores.

Heliopora aprutino Prever and *H. decipiensis* Prever,[5] from the Monti d'Ocre in the Abruzzo Aquilano (Cenomanian), are also similar. The specimens of the two forms described by Prever do not seem to be in a good condition of preservation, but one can be reasonably certain, at least, that the former of the two species is easily distinguished from *H. japonica* by having more crowded autopores and the latter by having autopores with somewhat more numerous pseudosepta and scanty coenenchyma. These Italian species need revision by microscopical examination of thin sections.

In the Lower Cretaceous deposits distributed along the eastern margin of the Kitakami Mountainland, this species occurs at nearly all of the fossil localities distributed within the villages of Tanohata-mura, Omoto-mura, Taro-mura, and Sakiyama-mura, in the Simohei District of Iwate Prefecture. Judging from the present day ecological conditions of the living representative of this coral, it can be assumed that the coral fauna of the Miyako region, which contains abundant specimens of *Heliopora*, must have been provided with a shallow coralline sea influenced by rather strong agitating current from the open sea.

Holotype.—In the collection of the Institute of Geology and Paleontology, Tohoku Imperial University, Sendai, Reg. No. 56594.

Type locality.—Southern cliff of Haipe, Tanohata-mura, Simohei District, Iwate Prefecture.

Formation and age.—The Moshi and Hiraiga sandstone of the Miyako Cretaceous Series (Lower Cretaceous).

Other localities.—Haipe, Tanohata-mura; Koikorobe, ditto; Moshi, Omoto-mura; Matsushima, near Moshi, ditto; Taro, Taro-mura; Hideshima, Sakiyama-mura; all within Shimohei District, Iwate Prefecture.

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[2] W. Gregory, 1900, *Polytremacis* and the ancestry of Helioporidae. Proc. Roy. Soc. London, p. 298, pl. 2, figs. 8a–c.

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[5] P. L. Prever, 1908, Anthozoa, in C. F. Parona, La fauna coralligena del Cretaceo dei Monti d'Ocre nell' Abruzzo Aquilano. Mem. per serv. alla descriz. della carta geol. d'Italia, vol. 6, p. 65, pl. 28, fig. 1, and pl. 1, figs. 18, 18a, 23; pl. 2, figs. 1, 1a, 2.

MANUSCRIPT RECEIVED JUNE 26, 1947.

EXPLANATION OF PLATE 60

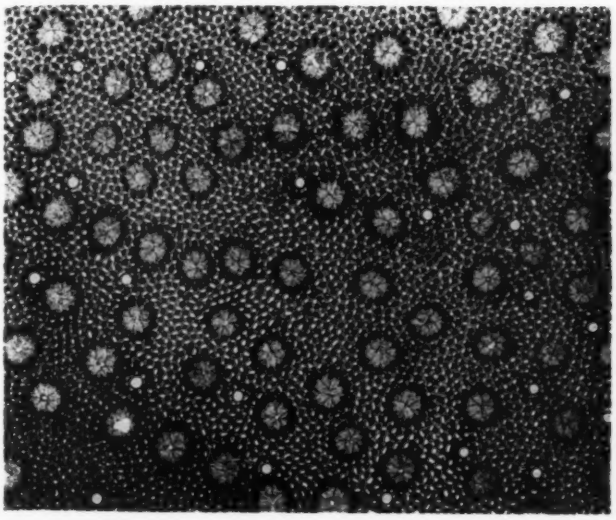
FIG. *1*—*Heliopora japonica* Eguchi. ×4. Weathered surface of specimen from Hideshima, Sakiyama-mura. The Hiraiga sandstone. Reg. No. 65925. (p. 363)

2, 5—*Heliopora japonica* Eguchi. (Type specimen). ×5. *2*, tangential section, *5*, vertical section. Specimen from north of Haipe, Tanohata-mura, in the Moshi sandstone. Reg. No. 56594. (p. 363)

3—*Heliopora coerulea* (Pallas). ×5. Tangential section. Specimen from Wotze, Marshall Islands. Recent. Reg. No. 48691. (p. 362)

4, 6—*Heliopora coerulea* (Pallas). ×5. Specimens from Kaikô, Koshun District, Takao Prefecture, Taiwan (Formosa), in the Raised Coral Reef. Reg. No. 39093. (p. 362)

7—*Heliopora japonica* Eguchi. ×4. Weathered surface. Specimen from a small islet near Moshi, Omoto-mura, Shimohei District. Moshi sandstone. Reg. No. 65990. (p. 363)



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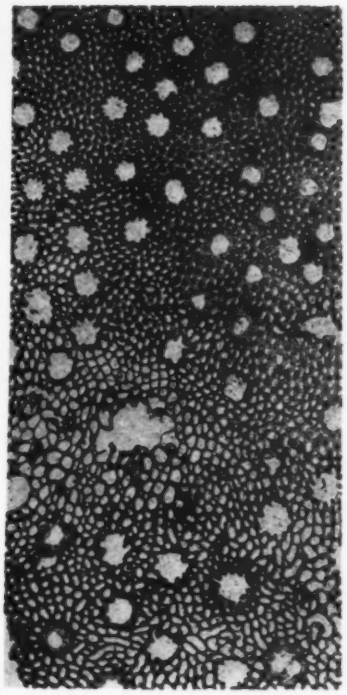

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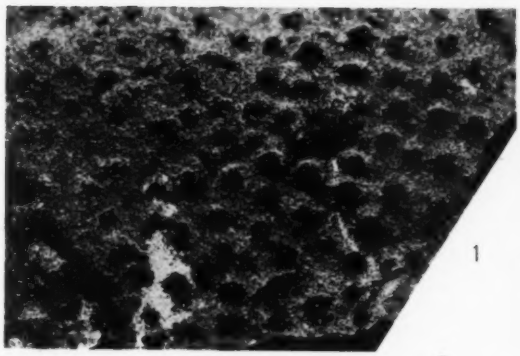

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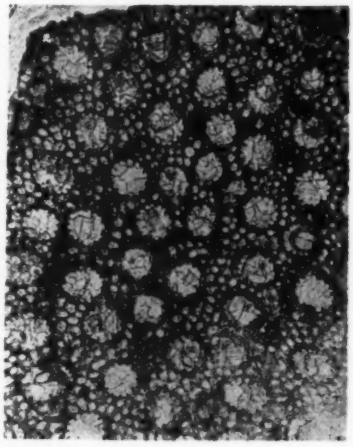

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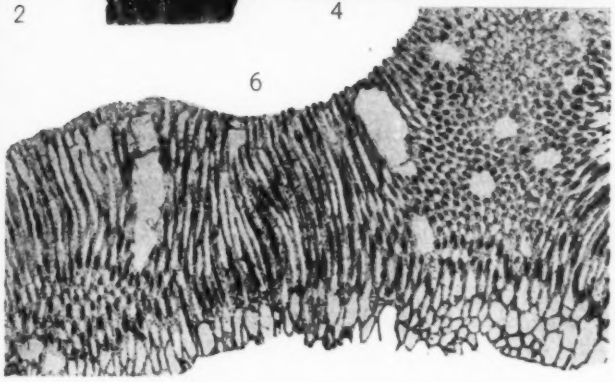

Eguchi, Fossil Pacific Helioporidae

JOURNAL OF PALEONTOLOGY, VOL. 22, NO. 3, PP. 365–367, 2 TEXT FIGS., MAY 1948

A NEW *SPONGIOMORPHA* FROM THE *ORBITOLINA* SANDSTONE OF IWATE PREFECTURE, AND ITS SIGNIFICANCE IN JAPAN

MOTOKI EGUCHI
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SPONGIOMORPHOID corals were studied in detail in 1890–1891 by F. Frech on materials derived from the Zlambach formation of the Alpine Upper Triassic. Many new localities and forms were added by later authors, from the Upper Triassic coralline rocks of the Alps, the Balkan Peninsula, Alaska, Oregon, California, and Timor. In Japan, such corals occur in the Torinosu limestone of Shikoku and of the Kwantô Mountainland. The Torinosu limestone was hitherto generally accepted as Jurassic among Japanese authors.

The recently obtained specimen, which is well preserved both in shape of corallum and in its inner structure, was collected from a good exposure near Akito in the environs of Raga, Hiraiga-mura, Shimohei-gun, Iwate Prefecture. This locality belongs to the *Orbitolina* sandstone, and besides yielding spongiomorphoid corals, numerous hexacorals were also collected from the same exposure. The *Orbitolina* sandstone is of Lower Cretaceous age, based upon the foraminifers and hexacorals.

The general acceptance that the spongiomorphoid corals indicate Jurassic age in Japan, and the belief that the Torinosu limestone contains beds of only one age, must now be revised, for the reasons to follow. First, in the so-called Jurassic Torinosu limestone, fossils occur which range from the Middle Jurassic to Lower Cretaceous in age, based upon hexacorals. Second, the occurrence of spongiomorphoid corals in the Lower Cretaceous upsets the long believed age-guide of them, and gives them a range from the Jurassic up into the Lower Cretaceous. Third, the Torinosu limestone is not a single unit indicating one geological age, but really includes many lenses which, on the basis of paleontological evidence and stratigraphic data, belong to more than one age and to more than one horizon. The name should, therefore, be considered as a facies rather than as a formational name. Fourth, the present paper is the first record of spongiomorphoid corals in the Lower Cretaceous.

The recently obtained material is described in the following.

Family SPONGIOMORPHINIDAE Frech
Genus SPONGIOMORPHA Frech
SPONGIOMORPHA (HEPTASTYLOPSIS) MIYAKOENSIS Eguchi, n. sp.
Figures 1 and 2

Description.—Corallum large, disc-shaped, thinning laterally, more than 300 mm. in diameter, and 50 mm. thick at the middle part and 2 mm. thick at margin. Surface uneven, with mammiform or short digitate protuberances, which measure 20–30 mm. at their bases; basal surface convex, pointed at center, ornamented with fine radial costae of slightly sinuous form, rarely with traces of calices arranged more or less in concentric rows, but very few, fewer than on upper surface. Calices small, 0.5 mm. in diameter, crowded on upper surface of corallum, their arrangement being more regular on mammilate protuberances; calicular centers variable in distance, usually 9 mm. apart. Coenenchyma well developed, formed of vertical and horizontal, rather irregular rods of skeleton material, of which the vertical elements are more regular and straight than the horizontal ones; perforations frequent, horizontal trabeculae usually very irregular, but sometimes arranged more or less radially and like the texture of sponges. Septa rather straight, 10 in number, subequal, thin, radiating from a group of small trabeculae at center of calyx, at rim of calices bifurcating and gradually merging into irregular spongy coenenchyma, which consists of some 6–7 trabeculae or small irregular rods in each 2 mm. Dissepiments well developed, numbering some 12 per 2 mm. Interspaces of trabeculae rather wide in general.

FIGS. *1*, *2*—*Spongiomorpha* (*Heptastylopsis*) *miyakoensis* Eguchi, n. sp. ×8. *1*, tangential section. *2*, longitudinal section.

Remarks.—The above described specimen is well preserved in the shape of its corallum and in its inner structure. At first sight, the specimen looked like *Polyphylloseris* sp., but when examined in sections, the characteristic features of *Spongiomorpha* (*Heptastylopsis*), as described and figured in this article, are well displayed. *Spongiomorpha* (*Heptastylopsis*) *gibbosa* Frech, the genotype, is similar to the present one in the form of the colony; however, the inner structure readily distinguishes the present one from that species. In cross-sections of conical protuberances, the radial arrangement of the skeletal elements is more distinct in the Japanese specimen, and, by its decameral septa, it can be distinguished from all previously described forms of the genus.

Holotype.—Preserved in the collection of the Institute of Geology and Paleontology, Tohoku Imperial University, Reg. No. 65328.

Type locality and horizon.—Small exposure near Akito in the environs of Raga, Hiraigamura, Shimohei-gun, Iwate-ken. The *Orbitolina* sandstone of the Miyako Lower Cretaceous, Lower Cretaceous.

The writer wishes to offer his warmest thanks to Miss Julia Gardner, of the United States Geological Survey, Washington, D. C., now on duty with the Engineer Intelligence Division, Office of the Chief of Engineers, General Headquarters, Far East Command, for kindly reading the manuscript.

JOURNAL OF PALEONTOLOGY, VOL. 22, NO. 3, PP. 368–374, MAY 1948

PALEONTOLOGICAL NOTES

COPE'S TYPES OF FOSSIL FISHES IN THE COLLECTION OF THE BUREAU OF ECONOMIC GEOLOGY, THE UNIVERSITY OF TEXAS

JOHN ANDREW WILSON
Department of Geology, The University of Texas

Members of the Geological Survey of Texas expeditions in the 1890's collected a considerable amount of fossil vertebrate material, part of which was submitted by Mr. E. T. Dumble, then Director of the Texas Survey, to Dr. E. D. Cope for identification. From this material Cope described several new genera and species. The specimens were returned to Texas, and in 1904 Montgomery published a list of those which were preserved in the Museum of The University of Texas. It is the purpose of this notice to call attention to the availability of the specimens and to give their catalogue numbers in the collection of the Bureau of Economic Geology. A list of the types of reptiles and mammals will be published later

Montgomery (1904) lists three fish types: "*Deltodes planidens* Cope," "*Mesodon diastematicus* Cope," and "*M. dumblianus* Cope." The synonymies for these types are as follows.

DELTODUS PLANIDENS Cope, 1894

Deltodus planidens COPE, 1894, Acad. Nat. Sci. Philadelphia Jour., ser. 2, vol. 9, p. 435, pl. 20, fig. 6. —HAY, 1902, U. S. Geol. Survey Bull. 179, p. 292.—MONTGOMERY, 1904, Biol. Bull., vol. 8, p. 57, ("*Deltodes*" by error).—HAY, 1929, Carnegie Inst. Washington, Pub. 390, vol. 1, p. 562.

Bureau of Economic Geology Collection Number 18561.

MACROMESODON DIASTEMATICUS (Cope) 1894

Mesodon diastematicus COPE 1894, Acad. Nat. Sci. Philadelphia Jour., ser. 2, vol. 9, pp. 443–444, fig. 5.—WOODWARD, 1895, Cat. Fossil Fishes British Museum, pt. 3, p. 213.—MONTGOMERY, 1904, Biol. Bull., vol. 8, p. 57.

Typodus diastematicus (Cope). HAY, 1899, Am. Naturalist, vol. 33, p. 789; 1902, U. S. Geol. Survey Bull. 179, p. 372; Univ. Texas Bull. no. 71, p. 4.

Macromesodon diastematicus (Cope). HAY, 1929, Carnegie Inst. Washington, Pub. 390, vol. 1, p. 699.

Bureau of Economic Geology Collection Number 18567.

MACROMESODON DUMBLEI (Cope), 1892

Microdus dumblei COPE, 1892, Am. Philos. Soc. Proc., vol. 30, p. 128 ("*dumbelii*" by error); 1892, Geol. Survey Texas, 3d Ann. Rept. 1891, p. 256 ("*dumbleii*" by error).

Mesodon dumblei (Cope). COPE, 1894, Acad. Nat. Sci. Philadelphia Jour., ser. 2, vol. 9, p. 444, pl. 20, fig. 7.—WOODWARD, 1895, Cat. Fossil Fishes British Museum, pt. 3, p. 213.

Mesodon dumblianus (Cope). MONTGOMERY, 1904, Biol. Bull., vol. 8, p. 57 (erroneous name from Cope's manuscript label).

Typodus dumblei (Cope). HAY, 1899, Am. Naturalist, vol. 33, p. 789; 1902, U. S. Geol. Survey Bull. 179, p. 373; 1916, Univ. Texas Bull. no. 71, p. 5.

Macromesodon dumblei (Cope). HAY, 1929, Carnegie Inst. Washington, Pub. 390, vol. 1, p.699.

Bureau of Economic Geology Collection Number 18560.

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MONTGOMERY, T. H., 1904, A list of the types of fossil vertebrates in the museum of The University of Texas: Biol. Bull., vol. 8.

WOODWARD, A. S., 1895, Catalogue of the fossil fishes in the British Museum, pt. 3.

MANUSCRIPT RECEIVED JUNE 24, 1947.

PALEOGEOGRAPHY AND NOMENCLATURE

EUGENE S. RICHARDSON, JR.
Chicago Natural History Museum

In checking the undetermined specimens of invertebrate fossils in the collection of the Chicago Natural History Museum last spring, I came upon a hundred or so trilobites among an unstudied fauna from the Tremadocian Apsey formation[1] of Newfoundland, which appeared very certainly to represent a new species closely allied to *Parabolina andina* (Hoek), a species known from several localities in Bolivia and Argentina. Having prepared a description of the Newfoundland form, I wrote to Professor Horacio J. Harrington, Director of the Institute of Geology of the University of Buenos Aires, asking for further information on *P. andina*, as it seemed that the two forms had more in common with each other than with the genotype of *Parobolina*, and might require separation as a new genus. His reply included an exhaustive summary of the characters of the known species of *Parabolina*, and concluded with the opinion, based on my photographs of the Newfoundland specimens, that the supposed new form was actually *P. andina*. With this conclusion I now find myself in entire agreement, having studied five specimens of *P. andina* collected in the Summer of 1947 by Dr. D. Russo from a new locality in Argentina (Abra de Zenta, in the Cordillera de Santa Victoria, west of Oran, Province of Salta) and sent to me by Dr. Harrington. These specimens are better preserved than any hitherto illustrated, and are identical with the Newfoundland ones. It is a matter of some surprise to find that a trilobite species in the early Ordovician sea had such a wide geographic range (about 70 degrees of latitude, crossing the Equator), but the fact of the similarity of the specimens cannot be overlooked.

This seems worthy of comment, as it is certain that there are many similar instances of widely ranging species whose recognition is obscured by the fact that they bear different names in different parts of their ranges. Correlation of widely separated beds depends upon a comparison of the contained faunas even more fundamentally than upon stratigraphic succession of similar lithologic units or upon relation to orogenic episodes, and it is therefore of the greatest importance to stratigraphy, and, ultimately, to paleogeography, that faunal lists be objectively prepared and critically examined for errors in the use of taxonomic names. This would appear to be an obvious counsel of perfection, but it bears repetition. Only too often a species is regarded as new because it is found in a new locality and because the published pictures of closely related (and possibly identical) forms look somewhat different due to imperfect preservation or to imperfect photographic reproduction. Suppositions that geographic and stratigraphic range are limited should in all cases be proven by reference to actual specimens. However much a fauna may appear to be isolated in its species content from other known faunas, the working hypothesis that all the forms composing it are equally limited in range should not be treated *ab initio* as a conclusion. These remarks apply as strongly to range in time as to range in space. To "demonstrate" a spurious stratigraphic restriction by applying different names to what may actually prove to be earlier or later appearances of one species is to remove the objective basis of paleogeography.

A related error, even more difficult to uproot from the literature after publication, is that of anticipating a change in the generic constitution of a fauna at a system boundary by applying different generic names on each side of the "break." New generic names are, of course, required at many points in the spectrum of species, and the development of new genera is greatest following the ecological disturbances recorded by breaks in the stratigraphic record. Since systems are recognized by assemblages of characteristic genera, and since paleogeography is based on correlations so established, it is important that one who applies a new generic

[1] The source of these specimens was recognized by Professor B. F. Howell.

name should not therein be influenced by the presence of what he may wrongly take for a systemic boundary. Once faunal lists so prepared become available, they are accepted as evidence of the thesis which gave them birth, and not only perpetuate, but immeasurably strengthen, a correlation which may have little objective merit.

MANUSCRIPT RECEIVED NOVEMBER 12, 1947.
Submitted with the permission of the Director, Chicago Natural History Museum.

ORTHOGRAPHY AND TYPE DESIGNATION OF *DICTYOCONUS* BLANCKENHORN (FORAMINIFERA)

DON L. FRIZZELL
University of Texas, Austin, Texas

Morphological and systematic studies of some Foraminifera that are homoplasts[1] of "*Dictyoconus* Blanckenhorn" (1900) have required an incidental consideration of that genus. As a result, it is evident that the name has been misspelled by all workers subsequent to its proposal. In addition, various authorities have been in error regarding the designation of the genotype of this stratigraphically important Upper Cretaceous and Eocene genus.

Paradoxically, neither incorrect spelling of the name *Dictyoconus* nor misconception as to the designation of a type has yet resulted in any confusion. It cannot be assumed, however, that this moratorium on rigid construction of the International Rules of Zoological Nomenclature will hold indefinitely, nor that confusion may not be introduced through an invalid type designation.

The purpose of this note is to direct the attention of foraminiferologists toward a petition which is being presented to the International Commission on Zoological Nomenclature,[2] requesting that the name *Dictyoconus* be preserved without change. At the same time, it is pertinent to point out the type designation by Cushman in 1933. The details of these cases are as follows:

Orthography.—"*Dictyoconus*" was introduced without description on page 419 of the second part of Blanckenhorn's paper. The name appears next in the form "*Dictyoconos*" in the text of page 432. The latter spelling was continued in the formal proposal of the genus (page 434) and six times more on pages 434 to 436. Blanckenhorn's intention undoubtedly was to spell the name "*Dictyoconos*"; the first usage is an *erratum* (whether of author, editor, or typesetter is of no importance). Nevertheless, Douvillé's (1901) casual emendation[3] has been accepted, insofar as I can discover, in all later references.

In presenting a petition to the Commission, I am influenced neither by considerations of etymology nor legalistics. The Commission is being asked only to validate the usage which students of the Foraminifera have accepted unanimously and by tacit agreement, thus forestalling such confusion as necessarily would follow a change to the technically correct spelling.

Genotype designation.—The original list of species of *Dictyoconus* included only *D. egyptiensis* (Chapman) (1900, pp. 11–12, pl. 2, figures 1–3, as *Patellina*) and *D. coralloides* Blanckenhorn, although other forms were recognized as belonging to the genus.[4]

[1] I am following Haas and Simpson (1946) in regarding the term "isomorphy" as synonymous with homoplasy.

[2] "Proposed addition to the Official List of Generic Names, under Suspension of Rules, of *Dictyoconus* Blanckenhorn (for *Dictyoconos* B.) (Protozoa, Foraminifera)." Submitted to the *Bulletin of Zoological Nomenclature* in September, 1947.

[3] "*Il faut donc adopter le nom nouveau de* Dictyoconos (*ou mieux* Dictyoconus) *proposé par M. Blanckenhorn.*"

[4] "*Zu dieser Gattung gehören zunächst die ge-*

Neither was designated as type in the proposal of the name.

The first unequivocal designation which I find is by Cushman in 1933 (p. 125), consisting of the unqualified statement following the generic heading: "Genotype, *Patellina egyptiensis* Chapman." A. M. Davies (1935, p. 11) could be considered to have fixed the type in the same manner. Moreover, L. M. Davies' (1939, p. 773) statement, that "the type of this genus is the species *D. egyptiensis* (Chapman)," would serve in the absence of earlier designations. Ellis and Messina (1940) therefore were in error in concluding that the type had not been designated.

Galloway (1933, p. 206) was incorrect in crediting this designation to Woodring (1924) since, as Ellis and Messina have shown, Woodring erroneously cited the species as type by monotypy. The same error prevents acceptance of Cushman's (1928, p. 182) listing of *D. egyptiensis* (Chapman) as "genoholotype" (that is, type by original designation or monotypy) of *Dictyoconus*.

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ADDENDUM

A manuscript copy of the foregoing was sent for comment to J. Brookes Knight, Chairman of the Joint Committee on Zoological Nomenclature for Paleontology in America, who does not agree with my concept of genotype selection. Dr. Knight, in company with a number of other outstanding nomenclaturalists, believes that the act of naming an available species as type or genotype (or equivalent term) is to be construed as selection, regardless of whatever errors of reason, interpretation, opinion, or even fact might be involved. Further correspondence on Dr. Knight's part, however, elicited the fact that several practicing taxonomists agree with the interpretation that I have given above.

Although the matter is insignificant in relation to *Dictyoconus*, it is of considerable importance in the evaluation of some other generic names. There seems no question that, from the point of view of logic and expediency, Dr. Knight's interpretation is the more desirable. It may, however, be considered to contravene the requirements of Article 30 of the Rules that: "The meaning of the expression 'select the type' is to be rigidly construed." At what point rigid construction becomes mere quibbling, of course, is a matter of semantics and of individual judgment.

It is probable that Dr. Knight and his associates at the U. S. National Museum will initiate a petition to the International Commission on Zoological Nomenclature, requesting clarification.

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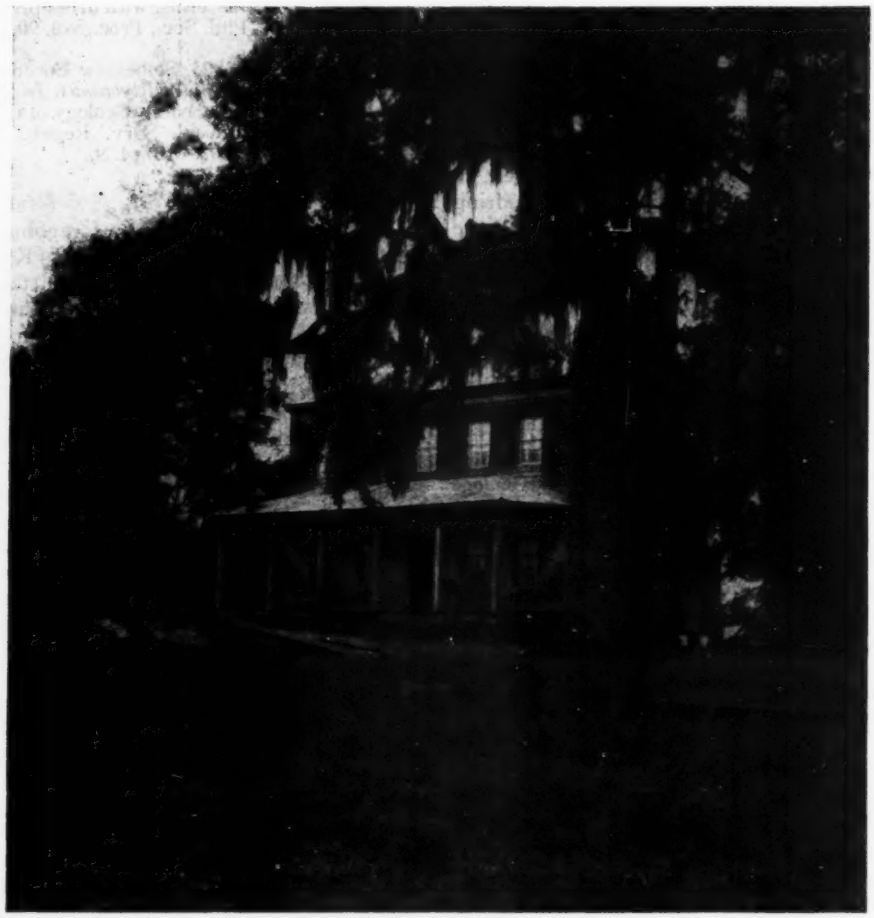
nannten Orbitolinen (?) Carter's [1861] *von Kelat in Afganistan aus Eocänkalk mit* Alveolina elliptica [pl. 17] *(f. 7) und von Sind in Indien aus Kalk mit* Orbitolites pedunculata [pl. 17] *(f. 8)*" (Blanckenhorn, 1900, p. 434).

COCOA SAND TYPE LOCALITY

WILLIAM D. TURNBULL
Chicago Natural History Museum

In the spring of 1947, a field party from the Chicago Natural History Museum went to western Alabama to collect in the Cretaceous Selma formation. A short side trip was undertaken to investigate a zeuglodon skull in the Jackson group, Eocene, near Old Cocoa post-office, 2½ miles east of Melvin, S.W. ¼ section 13, T. 11 N., R. 5 W., Choctaw County. Upon arrival, it was discovered that the post-office, which formerly marked the type locality of the Cocoa Sand member of the Yazoo Clay (Jackson group), no longer exists. Therefore, in order that we may again have a marker for this locality, I suggest the home of Mr. A. L. Pippen (pictured), the only two story structure in this vicinity. This building rests on the formation and is located across the road from the Old Cocoa post-office site. It should thus serve ideally to remark this locality.



By permission of the Director, Chicago Natural History Museum.

CAMBRIAN BRYOZOA MORE PRECISELY DATED

MADELEINE A. FRITZ
Royal Ontario Museum of Palaeontology

In my paper entitled "Cambrian Bryozoa" (JOUR. PALEONTOLOGY, vol. 21, no. 5, 1947, p. 434) I mentioned two trilobites that were associated with the bryozoan fragments, one *Bynumia*, the other *Elvinia*.

Dr. B. F. Howell has pointed out that the *Elvinia* is more probably a representative of the genus *Cedaria*. This genus is characteristic of the Lower Dresbachian, which is stratigraphically near the base of the Upper Cambrian. Later, James L. Wilson commenting on my *Elvinia* determination, states that *Elvinia* has never yet been found in association with *Bynumia*, the latter genus occurring consistently below *Elvinia* in all sections in the United States. Like Howell, he suggests that my fauna belongs to the Dresbachian stage of the Upper Cambrian.

I am greatly indebted to both of these paleontologists for their assistance in helping me date more precisely the strata in the Canadian Rockies that have supplied the first evidence in North America of Bryozoa from the Cambrian.

DICAELOSIA VERSUS *BILOBITES*

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I hesitate to annoy the already beleaguered bibliographers with one more nomenclatural note; but *Dicaelosia*, the animal whose name is in confusion, is a very common and distinctive brachiopod of Silurian and Lower Devonian strata in many parts of the world (the actual range is Richmondian to lower Middle Devonian), and delay in nomenclatural correction would only permit ancient error to become more deeply rooted.

The name *Dicaelosia* was proposed by King in 1850 (p. 106–107) with the Middle Silurian brachiopod *Anomia biloba* Linnaeus 1767 as the designated genotype. Subsequently *Dicaelosia* has been suppressed in favor of *Bilobites*, a name of confused history. *Bilobites* has been proposed three times as a generic name (Neave, 1939) but none of these uses invalidates *Dicaelosia* King. The earliest usage by Dekay in 1824 was apparently for a bivalved crustacean resembling the shells at present generally referred to *Conocardium* (Dekay, 1824, Pl. 5, figs. 1, 2, 4). Goldfuss in 1843 (p. 566) listed the name *Bilobites lunulata* Rafinesque under the Trilobita, but the name was there a *nomen nudum*. Quenstedt, 1869, applied the name *Bilobites* to the brachiopod, species *biloba* Linnaeus. Clearly *Bilobites* Dekay is the only one of these names that bears on the problem, and it does not apply to a brachiopod.

Actually the usage that is held to take priority over *Dicaelosia* King is "*Bilobites* Linné 1775" (Dall, 1897, p. 16; Schuchert and LeVene, 1929, p. 35; Schuchert and Cooper, 1932, p. 130). However, Linnaeus did not employ the name "*Bilobites*" in a generic sense in the reference cited by those who ascribe this name to him. As transcribed by Müller, he wrote "Der Bilobit. *Anomia biloba*" with "*Bilobit. Biloba*" as a side-heading (Linné, 1775, p. 325) in the same way as he used "Die stachliche Anomie. *Anomia spinosa*" with "Stacheliche Anomie. *Spinosa*" as a side-heading (p. 326), and "Die Perlenmutter. *Mytilus margaritiferus* with "Perlenmutter. *Margaritiferus*" at the side (p. 330). Names such as *Kammblat*, *Blatterkamm*, *Hahnenkamm*, *Transparant*, *Keil*, *Hysterit*, and *Terebratul*, were used by Linnaeus in the same publication and in the same sense as *Bilobit*. None of these other names are considered to be generic, and by the same token neither *Bilobit* nor *Bilobites* may be considered to have been established in a generic sense in 1775.

Therefore *Dicaelosia* King, 1850, must supplant *Bilobites* as a generic name among the brachiopods. The genotype, by original

designation, is *Anomia biloba* Linnaeus, and the name is spelled *Dicaelosia*, not *Dicoelosia*, as emended by Schuchert and LeVene (1929, p. 52). The family name Biblobitidae (Schuchert and Cooper, 1931), of course, automatically becomes Dicaelosiidae, as provided by Article 5 of the International Rules of Zoölogical Nomenclature.

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NOMINATIONS FOR OFFICES IN THE PALEONTOLOGICAL SOCIETY FOR 1949

In accordance with the provisions of Chapter IV, Section 1, of the By-Laws, the Council of The Paleontological Society announces the following nominations for offices in the Society for 1949:

For President, WINIFRED GOLDRING, Albany, N. Y.
For Vice-President, NORMAN D. NEWELL, New York, N. Y.
For Secretary, H. E. VOKES, Baltimore, Md.
For Treasurer, FRANK M. SWARTZ, State College, Pa.
For Editor, A. SCOTT WARTHIN, Poughkeepsie, N. Y.

ABSTRACTS AND NOMINATIONS

The attention of the members of The Paleontological Society is called to the following changes of dates made necessary by the fact that the annual meeting date has been moved to November from its regular after-Christmas position. Beginning with this year the closing date for the receipt of abstracts will be September 1 and for the receipt of nominations for membership, September 15. By action of the Councils of The Paleontological Society and of the Geological Society of America, no abstracts of papers to be read by title will be accepted for publication or for listing on the program of the annual meeting.

JOURNAL OF PALEONTOLOGY, VOL. 22, NO. 3, P. 388, MAY 1948

NOTICES

REQUEST FOR PALEONTOLOGICAL PUBLICATIONS

The library of the Geological Survey at Bratislava, Czechoslovakia was destroyed during the war. The Director of that Survey, Dr. M. Kuthan, will be grateful for any paleontological publications that American paleontologists can send to him. Such publications can be addressed to him at the Štátny Geologický Ústav, Palisády 46, Bratislava, Czechoslovakia.

B. F. Howell,
Secretary, the International Paleontological Union

SARDESON COLLECTION

The University of Minnesota Geological Museum has acquired by purchase from Dr. F. W. Sardeson his private collection of fossils comprising some 3,500 species, each represented by from one to 100 specimens. Most of the specimens were collected over a period of 50 years from the Ordovician rocks of Minnesota, Wisconsin and Iowa by Dr. Sardeson, whose faunal zonation, published in 1891, is still accepted. Another important element in the collection comprises Jurassic invertebrates collected in central Europe by Dr. Sardeson while he was a student at Heidelberg.

ERRATUM

In a recent paleontological note by Gordon Gunter (JOUR. PALEONTOLOGY, vol. 21, pp. 498–500) the word "not" was omitted from the last sentence of the penultimate paragraph. The corrected sentence should read "On the other hand I am not now prepared to make comparable general assertions concerning known effects of temperature on modern marine animals," etc.

PLATES FROM THE JOURNAL OF PALEONTOLOGY

For some years the Society of Economic Paleontologists and Mineralogists has offered for sale sets of the plates from its numbers of this JOURNAL, on a subscription basis. The surplus plates from all numbers of the JOURNAL are now being saved, and are available in addition to the subscription plates, in so far as the supply lasts. These separate plates are sold at the rate of 10 cents each for the first 10 plates ordered, and two cents for each additional plate in the order. Plates printed on both sides are sent in duplicate without additional charge, if both sides are ordered. Requests for plates from issues sponsored by either society should be addressed to the Society of Economic Paleontologists and Mineralogists, Box 979, Tulsa 1, Oklahoma.

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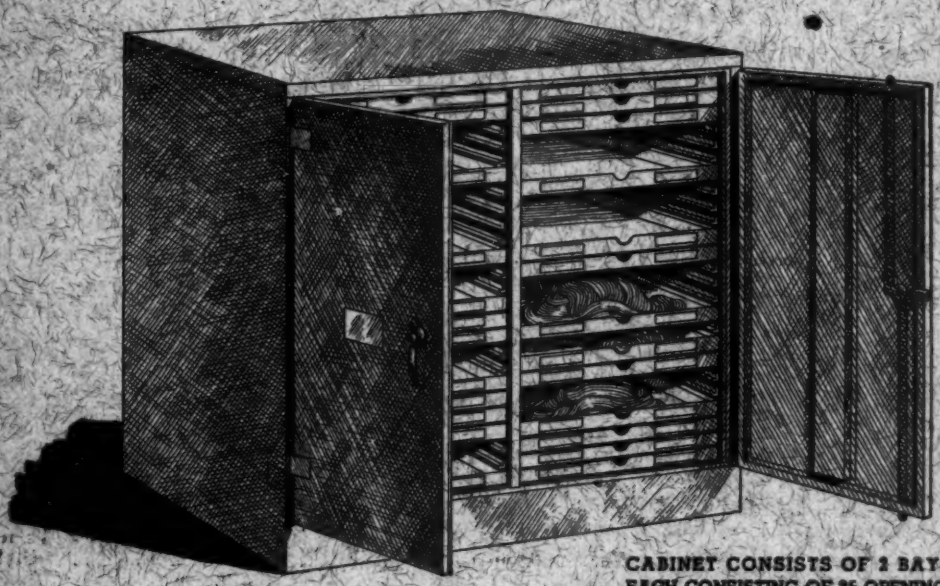

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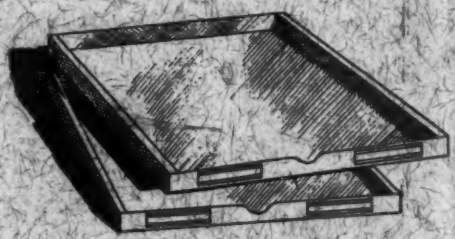

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